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Nr. 4. Johs. Schmidt: THE PELAGIC POST-LARVAL STAGES OF THE ATLANTIC SPECIES OF *GADUS*. A MONOGRAPH WITH 3 PLATES AND 16 FIGURES IN THE TEXT. (*ENGLISH EDITION.*) PART I

KØBENHAVN
I KOMMISSION HOS C. A. REITZEL
BIANCO LUNOS BOGTRYKKERI
1905

MEDDELELSER FRA KOMMISSIONEN FOR HAVUNDERSØGELSER
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THE PELAGIC POST-LARVAL STAGES OF THE ATLANTIC SPECIES OF *GADUS*

A MONOGRAPH WITH 3 PLATES AND 16 FIGURES IN THE TEXT

BY

JOHS. SCHMIDT

A second portion of this work will be published shortly. The contents of the second portion, which is based on the latest investigations of the "Thor" and is intended to complete this first portion, will consist chiefly of the following:

(1) description and figures of the youngest postlarval stages of *G. minutus* and *luscus;*
(2) figures of the older postlarval stages of *G. Poutassou,* as also a review of the distribution of the pelagic young of this species;
(3) description and figures of the whole postlarval developmental history of *Gadiculus argenteus,* as also a review of the geographical distribution of its pelagic young;
(4) further discussion and characteristics of the variations within the postlarval stages of the principal species of *Gadus.*

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CONTENTS

page

I. Introduction ... 1
II. The developmental history of the post-larval stages of the *Gadus*-species ... 8
I. Main group ... 9
1. *Gadus callarias* Linné, cod ... 9
2. *Gadus virens* Linné, green cod ... 12
3. *Gadus pollachius* Linné, pollack ... 17
4. *Gadus saïda* Lepechin, polar cod ... 24
On the mediolateral streak and the pigment bars in the first main group (*G. saïda, callarias, virens, pollachius*) 28
II. Main group ... 30
1st Subgroup ... 31
5. *Gadus aeglefinus* Linné, haddock ... 31
6. *Gadus merlangus* Linné, whiting ... 37
7. *Gadus Esmarki* Nilsson, Norway pout ... 40
8. *Gadus minutus* O. F. Müller, poor cod ... 46
2nd Subgroup ... 54
9. *Gadus luscus* Linné, pout ... 54
10. *Gadus Poutassou* (Risso), poutassou ... 57
Notes on the developmental history and the pigmentation in the second main group (*G. aeglefinus, merlangus, Esmarki, minutus, luscus, Poutassou*) ... 63
Appendix. *Gadiculus argenteus* Guichenot ... 64
III. On the determination of the *Gadus*-species in the pelagic, post-larval stages ... 67
Bibliography ... 73
Explanation of the Plates ... 75
Additional note and Errata ... 77

N.B. A number of observations have been made since the publication of the Danish edition and have been included along with some other corrections in this English edition.

I. INTRODUCTION

In the last ten years of the preceding century, after the epoch-making investigations of G. O. Sars on the pelagic eggs and young of the cod had appeared, assiduous efforts have been made in the study of the biology of the youngest stages of the various food-fishes. It was naturally of importance, first of all, to be able to distinguish the various species from one another in these young stages, where the external appearance was extremely different from that of the adult fish, and as in most cases practically nothing was known of the external appearance of the early stages, fisheries biologists had before them a very great yet very important work, which had of necessity to be done. It is self-evident, that a knowledge of the characteristics of, for example, the cod and haddock in all the various stages of life, so that one species may be distinguished from other nearly allied species, is the first condition for being able to study the biology of these species at all stages in any sea. Further, the early stages of these species must be known also, as any exact biological investigation in this direction will be impossible until the true systematic basis has been laid. To contribute to this end is the object of the present work.

The greatest part of the honour of laying the basis for our knowledge of the early stages of the food-fishes, especially of the gadoids, is due, apart from G. O. Sars, to British biologists, whose investigations have been carried on at various marine laboratories. Biologists from other countries have also contributed to the work later. The method of investigation, which has given the most valuable and trustworthy results, has been the artificial fertilisation and hatching in laboratories of the eggs taken from ripe fish. After the larvæ have escaped from the egg, the success has been attained as a rule of keeping them alive until the yolk-sac is absorbed, and the best opportunity was thus obtained of studying them in the living condition in the laboratories. It is clear, that this hatching-method must lead to certain results. A reliable starting-point is chosen by it, namely, the eggs taken from ripe fish, which the laboratories can in many cases procure through the fishermen or other way, and the determination of the respective larvæ is thus quite certain. By this method, indeed, it has been possible to describe and figure a comparatively large number of the larval stages of the *Gadus*-species. Amongst the investigators who have gained special merit in this regard, the following must be placed in the front rank, G. O. Sars, Mc Intosh, Prince, Holt, Cunningham, Ehrenbaum etc.

Whilst we are therefore fairly well-informed as to the larval stages of the various gadoid species, our knowledge of the older, pelagic, post-larval stages is more fragmentary and uncertain, and whole series of species thus remain entirely or partly undescribed. (Such are *Gadus virens*, *G. pollachius*, *G. saïda*, *G. Esmarki*, *G. minutus*, *G. luscus*, *G. Poutassou*). As matters now stand we are in a position to understand why this is so; it is due to two conditions. Firstly, these older, pelagic stages of the gadoids occur for the most part further out to sea, that is, further from the fjords and coasts where the investigations were especially made. Secondly, sufficiently strong fishing apparatus was lacking for the capture of the older pelagic stages in great quantity. Both these conditions have now been altered. After Norway

had equipped a large steamer, the "Michael Sars", in 1900 for fisheries investigations on the open sea, most of the countries participating in the international investigations have later obtained each its sea-going investigation-vessel. The investigations are thus no longer restricted to the coasts, and the apparatus for the capture of the young fishes have likewise been enlarged and improved. The result has consequently been, that the investigations of later years have collected a much larger material of the older pelagic young of fishes than the earlier investigators had at their disposal.

Two periods can thus be distinguished in the historical development of the investigations on the young of the gadoids and in general of the food-fishes, an earlier, in which the greatest part of the work was done in the laboratories and the most important results of which are to be found in an exact description of the larval stages reared in laboratories, and a later, characterized by the fact, that an essential part of the investigations is now also carried out on sea-going vessels further from the coast, and apparatus are employed so that even the older pelagic stages are taken in quantity.

The material, which forms the basis for the present work, has come for the most part from the waters around Iceland and the Færoes, and has been collected by myself on the research-steamer "Thor" by means of the young-fish trawl constructed by C. G. Joh. Petersen, an excellent apparatus with very great fishing-capacity, whose use may be recommended everywhere[1]. To show what quantities this apparatus can take, I enumerate below the postlarval, pelagic fish-young contained in a single haul[2] made on the 27th of June 1904 at West Iceland (65° 10·5′ N., 24° 05′ W.), depth: 79 meters. The duration of the haul was 30 min. and 85 meters of wire were out:

6035	*Gadus Esmarki*	34	*Sebastes sp.*
245	*G. callarias*	46	*Cottus scorpius*
242	*G. aeglefinus*	6	*Cottus bubalis*
15	*G. virens*	3	*Triglops Pingelii*
4	*G. merlangus*	2	*Agonus cataphractus*
1	*Molva molva*	1	*Gobius sp.*
2	*Motella sp.*	16	*Liparis sp.*
73	*Pleuronectes limanda & platessa*	2	*Centronotus gunellus*
26	*Pl. cynoglossus*	23	*Ammodytes sp.*
120	*Drepanopsetta platessoïdes*	50	*Mallotus villosus.*
2	*Zeugopterus norvegicus*	1	*Lumpenus sp.*

To this example many others might be added, which would show what enormous quantities of pelagic, post-larval young fish are brought up by using Petersen's young-fish trawl in the open sea. In quantitative regard an unique material has thus been at my disposal, and I have further been able to study this material in the living condition on board ship. Artificial hatching has also been carried out on board the "Thor" to a very considerable extent.

Hitherto, however, the most important results have been attained by the investigation of the pelagic, postlarval young taken in the young-fish trawl, as, owing to the richness of the material, I have been able to establish unbroken series of developmental stages of each single species for most of the species. By means of these series, the unknown species have been determined, and the order of procedure has been, to begin with such older stages as were so far developed, that they could be identified from characters similar to those which mark the adult fish. Then, earlier and still earlier stages were taken and compared with the older, and the determinations were in this manner, if the

[1] A short description of this apparatus is to be found in my recently published report: "Fiskeriundersøgelser ved Færøerne og Island i Sommeren 1903"; Skrifter udgivne af Kommissionen for Havundersøgelser, Nr. 1, 1904.

[2] This haul is far from being the richest in individuals made by the "Thor".

material was rich enough, successfully carried down to the youngest, post-larval stages, attention being directed to certain outstanding characters whose successive development could be followed through the developmental series.

The method thus employed for the determination of unknown, pelagic fish-young might be called the series-method, and it stands in contrast to the hatching-method referred to in that, instead of making the certain starting-point with the egg and following its further development onwards like the latter method, it begins at the opposite end with the oldest stages and follows the development backwards. The condition for being able to use the series-method is, that a large material has to be at disposal, but in such cases it will lead to certain results, especially if the material contains whole series of the species.

It has further been of great importance for the certainty of the determinations, that I have been able to study specimens of all the 10 true *Gadus*-species[1] occurring in North-European waters; naturally, much greater certainty is thus brought into the work than if only some few species were known, and the characters which can divide the species into larger or smaller groups are more easily detected and a view over the whole more readily obtained.

The ten species found in the northern Atlantic Ocean, whose young I have been able to study, are the following:[2]

Gadus saïda Lepechin	*Gadus Esmarki* Nilsson
Gadus callarias Linné	*Gadus Poutassou* (Risso)
Gadus virens Linné	*Gadus pollachius* Linné
Gadus aeglefinus Linné	*Gadus minutus* O. F. Müller
Gadus merlangus Linné	*Gadus luscus* Linné

In this list, the species are arranged as far as possible according to their occurrence from north to south, or more correctly, according to the temperature of the water-masses in which they occur as tender fry. This is principally from my own experience at Iceland and the Færoes, but the order of the series may possibly have to be modified for other waters. The 10 North Atlantic species of *Gadus* mentioned make very different demands on the temperature of the water in which they live; thus, *G. saïda* is distinctly a cold water form which reaches its greatest development in purely arctic regions, whilst *G. luscus* is just as distinctly a warm water form, as far as hitherto known, occurring especially on the western coasts of Europe. It is evident, therefore, that our investigations on the "Thor", carried out round Iceland and the Færoes particularly, could not bring in equally large materials of all the species. Yet, the principal regions for most of the *Gadus*-species fall within our region of survey; it is just in these waters, which occupy an intermediate position between the purely arctic mentioned and the warmer, where *G. saïda* and *G. luscus* respectively belong, that the genus *Gadus* attains its greatest development. Thus, of the 10 species, the 8 first-mentioned have been taken by the "Thor" at the Færoes and Iceland. The last two, *G. minutus* and *G. luscus*, on the other hand, are not represented in the collections of the "Thor", and *G. pollachius* also occurs there but rarely[3], which is in agreement with the fact, that these three species belong to more southern waters than the regions investigated by the "Thor". In order to obtain material of *G. minutus, luscus* and *pollachius*, I was obliged to consult other collections and therefore applied to the Marine Laboratory at Plymouth, whose director Dr. E. J. Allen kindly sent me several large collections of *Gadus*-young from the English Channel, which were of great interest as they contained

[1] And further the small deep-sea species *Gadiculus argenteus*, which is also ascribed to the genus *Gadus* by some authors, and which is to be mentioned after the description of the above species.

[2] The species are divided as in Lilljeborg's well-known work: "Sveriges òg Norges Fiskar", II, 1891, which must be especially noted as regards *G. luscus* and *G. minutus*.

[3] Some few older bottom-stages of *G. pollachius* have been taken at the Færoes.

just the three species I wanted, but on the other hand none of the others. In addition, I obtained a considerable material of *Gadus pollachius* from the Norwegian fisheries investigations through their director Dr. JOHAN HJORT. I would express my best thanks to both, as by giving materials for investigation over to me, they have contributed to make this work more complete than it would otherwise have been. To the director of the Irish fisheries Investigations, Mr. E. W. L. HOLT, and to the Zoological Museum in Copenhagen (Professor H. JUNGERSEN) I am also indebted for the loan of material.

To Dr. H. M. KYLE, who has kindly undertaken the translation of the work into English, I wish to express my best thanks.

In working out the material, my special object was to bring forward such differentiating characters as are apparent and easy to observe and describe. For those who have to sort out and determine a large collection of pelagic fish-young, it is a matter of great importance, if the specific determinative characters are easy to observe, so that one may avoid being obliged to examine into anatomical characters, as number of vertebræ etc., whose observation takes a long time. It has proved, that the character of the pigment and its distribution furnish excellent and easily discernible distinguishing marks for the post-larval, pelagic *Gadus*-young, both for the single species and for groups of species. I have therefore laid great weight on the study of the pigment, as may be seen from the following descriptions of the species. It is the distribution and intensity of the black pigment especially, which is of importance; partly because it is more characteristic than the yellow, which appears in the post-larval stages of most species, partly because the black pigment is the only one which is generally preserved in preserving-fluids, and in most cases indeed the biologists, who are engaged in the determination of the *Gadus*-young, will have to deal with preserved specimens. The best preserving-fluid for pelagic young, I know, is formalin in a 1—4 % solution of sea-water, and I do not hesitate to recommend it far before spirit, in which the animals lose their pigment much more quickly and further shrink more. In the Danish collections we have pelagic fish-young, which have remained in excellent condition in formalin for more than 3 years; whether they will continue to do so, I am naturally unable to say as yet; possibly, if one wishes to preserve the specimens for a long series of years, they should be transferred from formalin to another preserving-fluid. In any case, however, formalin is a preserving-fluid, which so preserves the specimens over several years, that they can easily be determined. This will be quite sufficient in most cases, when it is a question of the preservation of collections of pelagic fish-young obtained for biological purposes.

I may add, that on board the "Thor" when the young-fish trawl came up with its contents of fish-young, jelly fishes, crustacea and other pelagic organisms, I most often used the procedure of washing out the whole contents in a tub of sea-water containing some parts of strong formalin (ca. 40 %), and letting the whole stand, for some hours for example. By this means, all the organisms are killed (jelly-fishes, crustacea, etc.), which might damage the delicate pelagic fish-young, and these are so far fixed at the same time, that they can better withstand the manipulation necessary for sorting them out.

It is especially the postanal pigment, which is of importance for distinguishing the species. For the description of the pigment it is important to have some definite, short terms, and I shall therefore give a summary of the names I use.

1. Occipital pigment

The occipital pigment consists of an unpaired group of larger or smaller chromatophores, more or less close together, on the occipital region behind the eyes.

2. Abdominal pigment

On both sides of the trunk, pigment is found on the portion of the gut lying in front of the anus, and forms as a rule an oblique streak of pigment running from the anus along the posterior wall of the abdominal cavity. For the most part, however, it is often not superficial but is seen through the skin. It may also be more diffusely distributed over the sides of the gut.

3. Preanal pigment

This appears as an unpaired, median, ventral streak of pigment extending from the throat back towards the anus. In front of this, two branchial streaks sometimes occur, meeting together in front to form an acute angle.

The pigment so far mentioned is placed in front of the anus. Of greater diagnostic importance, however, is the pigment (postanal) lying behind the anus and consisting of the following portions:

4. Dorsal pigment

On each side and close to the base of the dorsal fin (fins) there is a streak of pigment, the chromatophores of which may either form a continuous, shorter or longer row, or also be interrupted by interspaces free of pigment, especially in the younger stages of a group of species (see fig. 5—9). These disappear later by the pigment fusing together so as to form the continuous streak mentioned. Most often the dorsal pigment is a narrow stripe, extending later, however, down the sides of the fish. The streak formed by the dorsal pigment may vary in length; as a rule, it extends from the part almost over the pectorals to or near to the caudal fin, and is thus postanal as well as preanal. Its foremost and most posterior portions are designated the anterodorsal and the posterodorsal pigment respectively. On the dorsal pigment sending down chromatophores on the sides, there appears the dorsolateral pigment (4a).

A streak of pigment quite corresponding to the dorsal pigment is the

5. Ventral pigment

which appears as a continuous or broken streak close to the base of the anal fin (fins). It extends posteriorly from the anus but is of different length in the different species. In a similar manner as with the dorsal pigment, the ventral pigment is distinguished into an anteroventral and a posteroventral portion. By the ventral pigment sending up chromatophores over the sides, there arises a ventrolateral pigment (5a), which may gradually, as the animal grows older, become united to the dorsal pigment, so that the sides are quite covered by pigment. This is the final result in most species when the pelagic stage is over, and the young fish seek the bottom.

In a group of species there appears, after the very youngest, post-larval stages are passed, a very characteristic streak of pigment, namely, the

6. Mediolateral pigment

This consists of a shorter or longer, horizontal streak of pigment along the middle line of the sides of the tail between the dorsal and ventral streaks. I call it, therefore, the mediolateral streak. Its most posterior portion is first developed as a rule, and just as was the case with the dorsal and ventral pigment, it may be unbrokenly continuous or consist of 2 separate portions. The mediolateral pigment is of great diagnostic importance and besides is very apparent.

7. Lateral pigment

By this is understood the pigment, which is distributed over the sides without being arranged as a mediolateral streak.

This summary may be sufficient for the time being; a more detailed account of the pigment will be found under the description of the separate species. For the rest, it is self-evident, that other characters than the pigment come also into use in distinguishing the species, and the more so the older the animals become: the pigmentation is throughout most characteristic in the earlier post-larval stages. The more the pigment extends over the whole of the sides in the older stages, the more the differences generally disappear, and one is in greater degree obliged to seek for the differentiating characters in other structures, concerning which information will be given in the next section. In the youngest post-larval and larval stages, on the other hand, no other characters are in general found to give ready and certain determinations but the kind and distribution of the pigment.

If we wish to study the pigment on the tiny fish-young but a few millimeters long, it is necessary to use high magnification, either a very powerful lens or better still the microscope. The method I employ is, to place a piece of white cardboard on the microscope ledge under the slide or watch-glass on which the little fish is laid. In this way, the object is examined by reflected light on a white background under high magnification (e. g. 50—70 times), and even the smallest black chromatophores thus stand out very sharply. I lay no little weight on the use of this method when the youngest stages are being investigated. Thus, for example, the youngest stages of the cod and green cod are in general readily distinguished under the microscope by using this method.

Before passing to the description of the various species, I shall at present give but a brief summary of the principal general features of the developmental history of the genus *Gadus*.

By larval stages, I mean the stages from the hatching of the larva until the yolk-sac is absorbed. Although a comprehensive work on the larval stages, based on new observations, would be very desirable, I intend to consider them only slightly here, as my observations are too imperfect with regard to several species. I may possibly return to them later.

By post-larval stages are meant, the stages from the absorption of the yolk-sac until the young fish has in the main attained the permanent characters. There are no sharp boundaries, however, for the termination of the post-larval stage; as a rule, it agrees to a certain extent with the termination of the pelagic-life, after which the young fish seek the bottom. The size at which the young *Gadus*-forms seek the bottom, i. e. cease to live pelagically on the surface or deeper down, is very different for the different species. For the most of these it can be said to hold, that they are most often still pelagic at a length of 25 mm., but otherwise, the condition is very various, and this apparently both for the different species and the different waters. Thus, for example, *G. merlangus, aeglefinus* and *Poutassou* have a considerably longer pelagic stage than, for example, *G. pollachius, virens* and *callarias*. And on the other hand, the pelagic life in the cod, for example, already ceases at a much smaller size in the Danish waters and North Sea than at Iceland, where I have found pelagic specimens of over 7 cm. in length[1], whilst in the North Sea, according to British authors, they are found in the shallow water of the coasts even at a length of about 3 cm. On the whole, the pelagic life seems to be longer in the northern than in the southern waters (see also later under *G. saïda*).

As the distinction between the older pelagic and the first bottom-stages is thus not sharp, I have in most cases included the youngest bottom-stages in this work, which has to treat of the earlier and later postlarval, pelagic stages.

The postlarval development begins when the yolk-sac is absorbed and the anus opens. The end of the notochord is quite straight and there is as yet no trace of true fin-rays. A continuous embryonic fin occupies the place of the future dorsal, caudal and anal fins. The pectoral fins are present as large, fan-shaped membranes without true rays. The ventral fins are not yet present, they only appear later as low processes, when the development of the rays in the unpaired fins is in general very far advanced.

[1] Hjort (1901, p. 102) has even found pelagic cod-fry 9 cm. in length in the waters between Bear Island and Norway.

The development of the rays takes its beginning in the unpaired fins, and in these again on the region of the caudal fin first of all. From thence, the development proceeds forwards, so that the first dorsal fin is the latest of all the unpaired fins to be developed.

I have mentioned, that the development began in the region of the caudal fin. The first things seen are two low folds above and below the backbone near its termination. From these folds, of which the lower is the longer, the interspinous rays develop. Similar separate folds appear later on the region of the dorsal and anal fins. At the same time, true rays begin to develop above and below in the caudal fin, whose central portion above and below the free end of the notochord is still however without true rays. When the development of the rays is further advanced in the caudal fin, rays also appear in the region of the various dorsal and anal fins nearest the interspinous rays, but the developing fins are still bound with the original embryonic fin. Meanwhile, the free end of the notochord has become bent upwards somewhat and rays also appear in the central portion of the caudal fin. The next step is, that the developing dorsal and anal fins as well as caudal fin become distinct, by the embryonic fin between them disappearing. Whilst the formation of the unpaired fins has been going on, rays are also laid down in the pectoral and ventral fins; but the first of these retain for a long time their larval appearance of large, fan-like flaps of skin. With regard to the various dimensions of the trunk, these change greatly during post-larval development. Thus, in the youngest post-larval stages the anus apparently moves backwards and later again forwards, and similar great changes take place in the position of other points. Concerning all this, reference may be made to the detailed description. It may be mentioned here, however, that the relative size of the eyes is much greater in the younger than in the older stages.

II. THE DEVELOPMENTAL HISTORY OF THE POST-LARVAL STAGES OF THE *GADUS*-SPECIES

Where nothing to the contrary is said, the following descriptions are based on the material from Iceland, taken by myself on the "Thor" in 1903 and 1904. With regard to both the gadoids and the flat-fishes, it has been found, that the pelagic life has often a longer duration in the Icelandic than in more southern waters (see p. 8), and that specimens of the same species at the same stage of development are often somewhat larger at Iceland than, for example, in the North Sea. I may use this occasion to remark, that the variation in size and partly also in the amount of pigmentation, which the young pelagic stages of the *Gadus*-species can thus show according to the waters in which they occur, is a fact which has to be taken into account, when a collection of pelagic *Gadus*-young is being worked at.

The descriptions are as far as possible made from typical, well-preserved specimens, and where nothing else is said, it is always pelagic specimens taken at the surface or in deeper water-layers which are referred to. For the sake of convenience, the following abbreviations are used in the descriptions: D^1 = 1st dorsal fin, D^2 = 2nd dorsal fin, D^3 = 3rd dorsal fin, A^1 = 1st anal fin, A^2 = 2nd anal fin.

With regard to the figures in the text and on Plates I—III, it may be remarked, that the specimens are taken as nontransparent, so that all the internal parts and organs are omitted. If, for example, we represented both the surface pigment and internal parts, such as muscle segments etc., distinctness would be easily sacrificed therewith.

Before beginning to the systematic description of the species, I may first mention, that a comparative study of the youngest bottom-stages[1] as well as of the pelagic stages of all 10 species has led me to the result, that the species can be divided into 2 main groups, according as a mediolateral streak of pigment is present or not[2]. We have therefore the following grouping:

I. Main Group. Mediolateral streak present:

1. *Gadus callarias* Linné
2. *Gadus virens* Linné
3. *Gadus pollachius* Linné
4. *Gadus saïda* Lepechin

II. Main Group. Mediolateral streak absent:

5. *Gadus aeglefinus* Linné
6. *Gadus Poutassou* (Risso)
7. *Gadus merlangus* Linné
8. *Gadus Esmarki* Nilsson
9. *Gadus minutus* O. F. Müller
10. *Gadus luscus* Linné

[1] When the young bottom-stages grow up, the superficial, mediolateral pigment-streak disappears and the permanent lateral line shows itself. But before the mediolateral streak disappears, the young fish has already assumed so many of the permanent characters, as e. g. position and form of the fins, number of fin-rays etc., that it can be recognised by means of these. I mention this here in order to show good reason for establishing the main grouping given above.

[2] In a preliminary notice, entitled: "Some Preliminary Remarks on the Identification of Pelagic Postlarval Forms of *Gadus*", which was published as manuscript in February 1904, I have already put forward this main grouping.

Above the descriptions of the development of the various species, which are always based on the material in my hands, I mention the principal literature. The works chiefly mentioned are those dealing with the post-larval stages and especially those which contain figures.

I. Main Group (Mediolateral streak present)

1. *Gadus callarias* Linné, Cod

Principal Literature and Figures:

G. O. Sars (1866 and 1879). — A. Agassiz (1882, pl. VIII, fig. 4—5). — Mc Intosh & Prince (1889, pl. XVII, XIX). — Mc Intosh (1897, pl. VI, fig. 5). — Mc Intosh & Masterman (1897, pl. IX). — Masterman (1900, pl. I—II). — Petersen (1902, fig. 1).

Postlarval pelagic stages of the cod are described and figured in the works cited of Agassiz, Mc Intosh & Prince, Mc Intosh & Masterman and Masterman, without however, so far as I can see, any positive proof being brought forward to show, that the young dealt with are really cod and not, for example, the nearly allied species of green cod (*G. virens*) or pollack (*G. pollachius*). Whilst there is an excellent, very characteristic figure by Masterman of the larval cod, reproduced in Mc Intosh & Masterman (1897, pl. IX, fig. 1), this cannot be said to the same extent in the case of the postlarval stages. The most recognisable figures of these stages are given by Masterman (1900, pl. I—II).

The very beautiful coloured drawings made by G. O. Sars showing the developmental history of the cod, which I have had the opportunity of seeing, have unfortunately never been published.

Description

$4^1/_2$ mm. The smallest specimens taken in the sea (at Iceland) measured $4^1/_2$—$4^3/_4$ mm. and agreed exactly with the older larval stages hatched on board. A comparison of my figure (pl. I, fig. 1) with Masterman's excellent figure of a larval stage (Mc Intosh & Masterman, 1897, pl. IX, fig. 1) permits one to readily follow the further development of the postanal pigment beyond the stage represented by the latter. The same three postanal bars are present as in Masterman's figure. For the sake of brevity, I shall call them 1, 2 and 3; 1 being nearest to the tail, 3 nearest to the anus. The various bars are at present sharply divided from one another into a dorsal and a ventral portion, each in the form of a line, whilst the part between is free of pigment. As indicated in the schematic Fig. 1, the ventral portions of the bars are denoted respectively as 1 V, 2 V and 3 V, the dorsal portions as 2 D and 3 D. 1 D is thus lacking normally[1], and 1 V consists most often of only a few subnotochordal chromatophores. Nevertheless, the pigment-bar 1, which can be made out normally in the cod, is of great diagnostic importance, as it is always lacking in the nearly allied species *G. virens* and *G. pollachius*[2].

Pl. I, Fig. 1

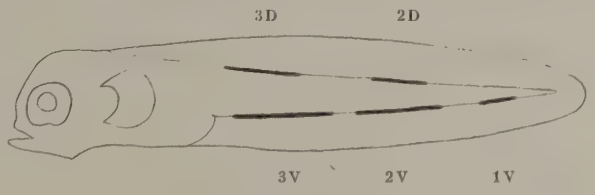

Fig. 1. Plan of the postanal pigment in the youngest post-larval stages of *Gadus callarias*

For the rest, bars 3 and 2 are sometimes even at this stage in process of fusing together. This holds especially for 3 V and 2 V, whilst 3 D and 2 D are more separated. In both cases, the position of

[1] The ventral pigment in the youngest postlarval stages here is generally, on the whole, in contrast to the condition in *Gadus virens*, more strongly developed than the dorsal.

[2] To make sure that this posterior bar, which often indeed consists of only a few chromatophores, is present, high magnification is sometimes necessary. A piece of white paper or cardboard should then be placed on the microscope stage under the slide containing the little fish, and this can then be examined against the white background by reflected light. It can thus very often be seen at the first glance, whether a cod or green cod is present (cf. p. 6). The few chromatophores composing 1 V may sometimes extend partly even on to the fin.

the original bars is still distinctly seen by the stronger pigment there. It is of importance, that 2 V generally extends further back than 2 D.

Concerning the pigment it has also to be remarked, that there is a distinct preanal streak which posteriorly reaches almost to the anus. The occipital pigment consists of a few large, branched chromatophores, and there is also a distinct, oblique streak of abdominal pigment. There are no signs whatsoever of rays or interspinous rays.

Pl. I, Fig. 2 & 2a

6½ mm. Very slight indications of the interspinous rays are present in the region of the caudal fin, where they appear as slightly less transparent parts under and above the notochord. Otherwise, indications of interspinous rays and fin-rays are quite wanting.

The pigment shows a difference from the previous stage, in that both 3 V and 2 V and 3 D and 2 D are now fused together to form a ventral and dorsal streak. (See fig. 2a, pl. I.) The original condition can however be recognised, as the pigment, which unites the original bars, is weaker than these; also, the separation may still be distinct in specimens of the same size or even larger. The dorsal and ventral lines do not end so abruptly posteriorly as in *G. pollachius* and *virens*[1]. Most often, the ventral pigment streak extends posteriorly further than the dorsal streak (in contrast to *G. virens* and *pollachius*). A mediolateral pigment streak has now begun to appear and is already fairly well-marked, especially between 2 D and 2 V. Further, the dorsal and ventral pigments give off a few chromatophores, especially the former, so that there is now also a little dorso-lateral pigment there.

Pl. I, Fig. 3

9 mm. The end of the notochord as in the foregoing stage is quite straight. Indications of rays are now present above and below in the caudal fin. On the parts where the dorsal and anal fins will later appear, indications of the interspinous regions appear as low, faint folds, but traces of fin-rays are still quite wanting. The original arrangement of the postanal pigment into bars has practically disappeared, and the mediolateral as well as the dorsolateral and ventrolateral pigments are now stronger. The ventral pigment extends further back than the dorsal pigment. None of these pigment streaks are very sharply marked-off posteriorly, and 1 V near the end of the tail is still present in the form of some few chromatophores.

Concerning the yellow pigment in living specimens of this size, it may be said, that the sides are not so strongly yellow as in *G. virens*. The yellow pigment is found especially on the dorsal and ventral as on the dorso- and ventrolateral aspects, but not on the mediolateral.

Pl. I, Fig. 4

11 mm. The posterior part of the notochord is very slightly bent upwards; the length of the free end is about half as great as the distance of its posterior point from the posterior border of the caudal fin. Rays are now present on the greatest part of the caudal fin except on the portion round the end of the notochord. There are slight indications of rays in A^1, A^2, D^2, D^3 but not in D^1. The pigment is more abundant and more diffuse, but otherwise essentially as in the foregoing stage. 1 V consist of a single chromatophore. The ventral pigment (2 V) reaches further back than the dorsal pigment (2 D). Both decrease gradually in amount posteriorly.

Pl. I, Fig. 5

13 mm. Only a small portion of the caudal fin nearest the end of the notochord is now lacking in rays. Indications of rays in the other unpaired fins are now more distinct and more numerous. The first weak traces of rays can now be detected in D^1. The following number of distinct ray-indications can be counted: D^2 = ca. 13, D^3 = ca. 12, A^1 = ca. 13, A^2 = ca. 11.

[1] Masterman (1900, p. 7) says concerning this: ". . . the dorsal and ventral lines do not here (i. e. cod), nor at any stage reach actually to the tail, but end suddenly at some distance therefrom". So far as my observations go, this is not characteristic, as the green cod and pollack are distinguished from the cod just by the pigment posteriorly coming more suddenly to an end somewhat in front of the tail. In the cod it does not end quite so suddenly, but decreases more uniformly posteriorly, even if in such young stages it does not yet fuse together with the few chromatophores of 1 V.

The developing rays in the dorsal and anal fins do not yet reach out quite to the margin of the embryonic fin, which is still present, so that the developing fins are thus bound by a broad, connecting membrane. The ventral fins can be seen with the aid of a strong lens as small, knob-like processes.

The pigment has not essentially altered, it extends quite out over the tail, and more pigment is constantly being developed between the mediolateral streak and the dorsal and ventral streaks. The last of these especially has moved somewhat from the ventral margin up on to the side.

16 mm. The length of the free end of the notochord is ca. $^1/_3$—$^1/_2$ of the distance from its end to the posterior border of the caudal fin. There are distinct, but few, indications of rays in D^1, which is, however, still very low. The embryonic membrane between the developing unpaired fins is rather low, and the middle rays in the dorsal and anal fins now extend out to the margin. The portion of the caudal fin nearest the end of the notochord is now no longer free of rays. The ventral fins are no longer like knobs, even though still very small, scarcely half as long as the diameter of the eye. The position of the anus is under the foremost part of D^2. The pigment has not essentially changed, but several chromatophores are present on the sides. Both the mediolateral and preanal streaks are distinct. The first reaches forward to almost opposite the middle of D^2. The pigment streaks do not end abruptly towards the end of the tail. Pl. I, Fig. 6

The faint, yellow pigment, found in the living specimens, has also developed since the last described stage (9 mm.), where in the postanal region it was especially restricted to the neighbourhood of the dorsal and ventral streaks. In addition, there is now a very faint yellow colour on the middle of the sides. The foremost part of the abdominal region has begun to assume a slight silvery sheen.

20 mm. The length of the free portion of the notochord is now only ca. $^1/_5$ of the distance of its point from the posterior border of the caudal fin. With exception of D^1, which is still relatively very low, the unpaired fins have now apparently obtained their full number of rays (A^1 = ca. 20, A^2 = 18), and the dorsal and anal fins are now nearly separated. The difference in length between A^1 and A^2 is but small. The posterior border of the caudal fin is almost straight across. The ventral fins are still very small, about the same length as half the diameter of the eye. All the fins are free of pigment. The position of the anus is under the beginning of D^2. The pigment has essentially the same relations as in the preceding stage, but is somewhat more evenly distributed over the whole side, likewise the mediolateral streak is still very distinct, and the same holds for the preanal streak. Anteriorly, the mediolateral streak reaches in general quite to a line through the middle of D^2. Pl. I, Fig. 7

The postanal, yellow pigment is now diffusely distributed over the whole side, but is very faint.

30 mm. The specimen (from Iceland) examined and figured was still pelagic, but in more southerly waters, as e. g. the North Sea and the Danish waters, the young cod of this size are often already seeking the bottom, and have assumed the characteristic pigmentation of the young bottom-stages (see e. g. M'Intosh and Prince, 1889, pl. XVII, fig. 8). The unpaired fins are now quite separated, but D^1 is still comparatively low. A little pigment is present on D^1 and D^2 as also on A^1. The caudal fin ends almost squarely and is tolerably narrow (cf. *G. pollachius*). The anus is placed under the beginning of D^2. A^1 had 20 and A^2 18 rays. The lengths of the bases of the two last-mentioned fins are not very different, but A^1 is a little longer than A^2 (cf. *G. virens* and still more *G. pollachius*, where the base of A^1 is much longer than that of A^2). The ventral fins have increased in length; they now measure scarcely 3 mm., are considerably larger than the diameter of the eye and extend about halfway to the anus (measured from their base). Pl. I, Fig. 8

The postanal pigment is now diffusely distributed over almost the whole side even to the caudal fin; but the chromatophores are not particularly close together. The mediolateral streak reaches forward almost to the middle of D^2 and is still very distinct. On the other hand, there is now practically nothing

left of the preanal streak, which in other specimens is still however distinct. The occipital pigment is very dense.

On living specimens of this size it is seen, that the yellow pigment is quite diffusely spread over the sides and extends even to the caudal fin. There is also yellow pigment dorsally and ventrally. The yellow pigment is composed of small points between the black chromatophores. The abdominal region is now almost entirely of a silvery sheen.

Pl. I, Fig. 9 **46 mm.** Fig. 9, Pl. I represents a young bottom-stage from Iceland, showing the characteristic, chequered pigmentation, which makes the cod at this stage so easily distinguishable from all other species at the first glance. The chequered pigmentation of the young cod was already well-known from G. O. Sars and has also been figured (Agassiz 1882, pl. VIII, fig. 5; Mc Intosh & Prince 1889, pl. XVII, fig. 8; Mc Intosh 1897, pl. VI, fig. 5; Petersen 1902, fig. 1); it is not necessary therefore to describe it more closely. The figure on pl. I shows it sufficiently clearly [1]. Fairly distinct pigment is now present on the central portions of D^1 and D^2, less on D^3 and A^1. On the basal portion of the caudal fin there are some small points. The mediolateral streak is about to disappear, but remnants of it are still obvious. D^1 is now much higher than previously, and the unpaired fins have on the whole assumed essentially the same form as in the adult fish. The caudal fin ends almost squarely. The ventral fins are ca. $5^1/_2$ mm. long or about $^3/_4$ of the distance from their base to the anus. A large barbule is present. A^1 had 21, A^2 18 rays, and the lengths of their bases are not very different. The anus lies under the beginning of D^2.

Material

All the post-larval developmental stages of this species, which occur in the "Thor"'s collections from the Færoes and Iceland to the number of several thousands, are sufficiently well-known.

Verification of the determinations

This is given later, after the related species *G. virens* and *pollachius* have been described.

Occurrence within the region investigated [2]

Post-larval stages are found in quantities around the Færoes. In the months immediately after the spawning time they are found in quantities in the coastal waters off the south and west of Iceland, also later on in summer off the north and east of Iceland.

In the Danish waters within the Skaw (Kattegat and the Belts), pelagic post-larval young cod do not occur in great number in general (Petersen 1902). Of the cod-group (*G. callarias, virens, pollachius, saïda*), the cod is the only species whose pelagic young are found in the Danish waters within the Skaw.

2. *Gadus virens* Linné, Green Cod

Principal literature and figures:

Larval stages: Mc Intosh (1894, pl. II and III, fig. 1–5). — Mc Intosh & Masterman (1897, pl. X, fig. 4–5). — Post-larval stages: undescribed. — Young stages: Mc Intosh & Prince (1889, p. 823–824). — Mc Intosh & Masterman (1897, pag. 268—69).

Whilst the larvæ of the green cod are known from Mc Intosh's description and figures, this is not the case with the post-larval stages, unless indeed some of the small fish described as cod should be

[1] The smallest Icelandic specimens with chequered pigment were 35 mm. long; but in general this chequered arrangement is first reached about 40 mm. In the Danish waters (Little Belt) I have seen specimens of 25 mm. in length with distinctly chequered pigmentation.

[2] In this work, only an extremely brief review over the occurrence of the pelagic young of the various species within the region investigated is given. This subject will later form the object of a more detailed description accompanied by charts.

green cod[1]. Thus, the postlarval gadoid of 9·25 mm., which is figured by Mc Intosh (1894, pl. III, fig. 7), by Mc Intosh & Masterman (1897, pl. X, fig. 6) and referred doubtfully to *G. virens*, is certainly not a green cod, as will appear from the following description and the figures on Plate I. Some figures of the bottom-stage by J. Pentland Smith (pl. X, fig. 7—8), given in Mc Intosh & Masterman, do not seem to me fortunate, however, as they neither represent the young green cod's characteristic pigmentation sufficiently nor the remaining characters. For the rest, the youngest bottom-stages have been mentioned several times by the British authors, e. g. by Mc Intosh & Prince (1889, p. 823—24), Mc Intosh (1897, p. 145), Mc Intosh & Masterman (1897, p. 268).

Description

4 mm. The smallest specimens of this species taken in the sea (at Iceland) measure 4 mm. The tail is quite straight and there is no trace of interspinous rays. Pl. I, Fig. 10

The postanal pigment is very characteristic. It consists of the two foremost pair of bars as in the cod, namely, 2 and 3 (see fig. 1 and 2); on the other hand, the third or most posterior (1) is quite wanting.

In all the several hundreds of young green cod I have examined, there was no trace whatsoever of the most posterior bar, which is normally present in the cod even in the youngest larval stages as some few, subnotochordal chromatophores.

The bars 2 and 3 are here very distinctly separated, as well as shorter and broader than in the cod; the single bars are likewise most often more sharply marked off than in the latter. The dorsal portions of the bars are somewhat longer than the ventral, and on the whole the dorsal pigment in these youngest post-larval stages is more strongly developed than the ventral, in contrast to the condition in *G. callarias*. As the posterior bar (2) is rather short, a very large portion of the tail is free of pigment (in contrast to *G. pollachius*). Traces of the mediolateral streak are already present in the form of a single chromatophore centrally between 2 D and 2 V and one between 3 D and 3 V.

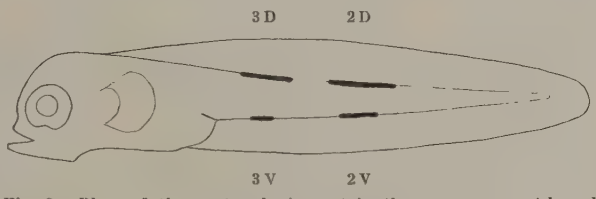

Fig. 2. Plan of the postanal pigment in the youngest post-larval stages of *G. virens*.

On the trunk itself, there is a little occipital pigment, consisting of a few stellate chromatophores, as well as the usual abdominal streak on the roof of the abdominal cavity (within this). On the other hand, the preanal streak is weaker than in the cod, and consists only of some few spots on the throat, so that it does not extend so far back towards the anus as in the cod.

5¼ mm. A slight indication of interspinous rays is now present in the caudal fin, especially subnotochordally. On the other hand, there are no indications of rays whatsoever. The pigment is essentially as in the previous stage.

6¾ mm. There are extremely slight indications of rays in the caudal fin both above and below; elsewhere no trace of rays can be seen. The mediolateral streak is now distinct; it is strongest posteriorly, but traces are also found opposite bar 3. 3 V and 2 V are still quite distinct, but 3 D and 2 D have partly begun to fuse together. For the rest, the dorsal portions of the postanal pigment bars are generally much stronger than the ventral portions. 3 V is the weakest and shortest of the bars. The preanal pigment is still but little apparent and does not extend further back than the pectoral fins. The occipital pigment is fairly well-developed; it is sharply divided from the dorsal pigment. Pl. I, Fig. 11 & 11a

[1] For example, the specimen figured by Hensen & Apstein (1897, pl. III, fig. 21).

Pl. I, Fig. 12 **9 mm.** The end of the notochord is still quite straight. Distinct indications of rays are present above and below in the caudal fin. In the anal fins as in D^3 and D^2, indications of the interspinous regions are seen as low folds. Concerning the pigment it has to be remarked, that 3 V and 2 V are still separate, which is the case as a rule at this stage. Sometimes, however, I have found them partly or altogether fused.

3 D and 2 D are quite fused to form a dorsal streak, which is much stronger than the ventral pigment, where 3 V especially is weak. It also extends a little further back than the ventral part, but both end abruptly posteriorly.

In living specimens, a number of small, yellow points are seen distributed over the sides between the dorsal and ventral pigment, giving the lateral aspects a yellowish tinge; posteriorly, the yellow pigment extends no further than the black. In preserved specimens also, a tinge is seen on the sides between the dorsal and ventral pigments, which has the further effect, that the pale termination of the tail stands out in sharp contrast to the pigmented portion of the sides.

The mediolateral streak is also now distinct between 3 D and 3 V. Further, there is now some dorso- and ventrolateral pigment opposite the original bars, but on the other hand nothing opposite the interspaces between bars 3 and 2, where even the mediolateral streak may be broken and where the yellow pigment in living specimens is also but weak. This all causes a kind of lighter, rounded spot to appear at this part, opposite the interspace between the original bars, which can be readily noticed in examining the figures of Pl. I. From this, one can often distinguish with ease the early post-larval stages of the green cod from similar stages of *G. callarias* and *pollachius*, even at the first glance.

Pl. I, Fig. 13 **11 mm.** The free end of the notochord is now a little bent upwards; its length is from $^1/_2$—$^1/_3$ of the distance between its terminal point and the posterior border of the caudal fin. The greatest part of the caudal fin is provided with rays. Further, there are indications of fin-rays both in the anal fins and in D^3 and D^2 (most distinct in D^3).

The mediolateral streak is distinct, but often broken, so that it consists of 2 portions, the one anterior opposite bar 3, and the other posterior (and more distinct) opposite bar 2. The pigment otherwise is not essentially different from in the foregoing stage; as in the following stages also, the sharply marked-off, pale terminal portion of the tail and the lighter rounded part on the sides between the original bars 2 and 3 are still apparent. The dorsal pigment is much stronger than the ventral. Regarding the fish from above, it is seen, that the original bar-arrangement of the dorsal pigment has quite disappeared, whilst in the ventral pigment it still occurs very distinctly. In some of the specimens examined, however, it was more indistinct. The preanal pigment is still but weak and limited to the part near the throat.

Pl. I, Fig. 14 **12$^1/_2$ mm.** Only a small part of the caudal fin on both sides of the free end of the notochord is now lacking in rays. Distinct indications of rays are found in all the unpaired fins with exception of D^1, where none are yet to be seen. The rays do not reach quite out to the margin of the embryonic fin, which enfolds the developing rays. The ventral fins can be seen by good light with a good lens as low knobs. The anus is placed immediately in front of D^2. The pigment has not essentially altered. The pale, sharply marked termination of the tail can still be remarked against the pigmented portion of the sides, likewise the light spot on the side. The ventral pigment is weak. Looking at the fish from below, the original pigment streaks 2 V and 3 V can however still be observed.

Concerning the coloured pigment in living specimens I may observe that, in addition to the yellow chromatophores which usually appear in *Gadus*-young of this size between the black occipital chromatophores, there is also yellow pigment on the sides as far back as the black pigment reaches. The yellow chromatophores are found as small points spread over the sides giving them a yellow tinge. Anteriorly (between 3 V and 3 D) there is often less yellow pigment than more posteriorly (between 2 V

and 2 D). In addition, yellow chromatophores are present amongst the black of the dorsal and ventral pigment. The foremost portion of the abdominal region may have assumed a silvery sheen even at this size.

15 mm. There is no longer any portion of the caudal fin free of rays. The length of the free end of the notochord is now only ca. 1/6 of the distance between its hindmost point and the posterior border of the caudal fin. The central rays in the anal and dorsal fins reach out to the margin of the embryonic fin, which however is still fairly broad. In A^2 ca. 18 rays could be counted, in A^1 ca. 20 rays, in D^1, which is still far back in development, only ca. 5. The posterior border of the caudal fin is a little concave. The anus lies a little in front of the developing rays in D^2. The ventral fins are no longer knob-like, yet still extremely small, not 1/4 of the diameter of the eye. The snout (distance from its end to the eye) is very short and blunt, distinctly shorter than in the cod, where at this size it has already begun to be a little more pointed. Pl. I, Fig. 15

The pigment is in the main unchanged, but denser, especially on the sides between D^3 and V^3 and D^2 and V^2 respectively, and thus the lighter pigmentless part already mentioned still stands out clearly, especially when the mediolateral streak is broken at this part, as is often the case. The mediolateral streak extends forward to almost opposite the beginning of D^2. Posteriorly towards the end of the tail, the pigment terminates abruptly as usual, but has begun nevertheless to extend a little further back; this holds especially for the mediolateral streak, which projects a little beyond the dorsal and ventral pigment. The last is much weaker than the dorsal pigment. The preanal pigment is still weak.

20 mm. The free end of the notochord is now much less distinct than before, so that its length is scarcely 1/6 of the distance from its hindmost point to the posterior border of the caudal fin. The unpaired fins are now almost separated. A^2, whose basis is distinctly shorter than that of A^1, has at least 21, A^1 at least 25 rays. A^1 is very low, lower than in the cod. The anus lies under the hindmost portion of D^1, which is still very low. In D^2 partly also in D^1, there are distinct black pigment spots between the rays. The ventral fins are pointed, but very small; their length is not 1/2 of the diameter of the eye. The pigment on the sides is now spread out and very dense; yet the lighter part on the sides centrally can still be detected, the chromatophores being less dense there. The pigment also extends further posteriorly than before and now reaches to the foremost part of the caudal fin, but the unpigmented end of the tail is nevertheless still clearly marked off. Of the three pigment streaks (dorsal, mediolateral and ventral), it is either the first or the second which extends furthest backward. Anteriorly, the mediolateral streak reaches to about the beginning of D^2. Pl. I, Fig. 16

23 mm. I have drawn a specimen of this size in order to show, how the pigment on the sides has gradually spread right out on to the tail, whose extreme point however is still free of pigment. Further, there is now pigment both on the dorsal and anal fins, most on D^1, D^2 and A^1, less on D^3 and least of all on A^2. D^1 is still low. A^1 has 26 and A^2 21 rays. The mediolateral streak reaches forward to the beginning of D^2. The anus is placed under the posterior third of D^1. A^1 is distinctly longer at the base than A^2. Pl. I, Fig. 17

30 mm. D^1 is now higher than the other dorsal fins. In these as in the anal fins, there is a considerable amount of pigment, especially on the first two dorsal fins. There is but little pigment on the caudal fin. A^1 has 28, A^2 22 rays. The anus lies under the posterior third of D^1 and its distance from the end of the snout is almost equal to its distance from the interspace between the caudal fin and A^2. (In the cod, this distance reaches from the anus out on to the caudal fin, in the pollack to about Pl. I, Fig. 18

the middle of A^2). The snout is short and blunt. The posterior border of the caudal fin is concave. The base of A^1 is longer than that of A^2. The ventral fins are still very short, barely 2 mm. long or scarcely so long as the diameter of the eye; they reach about half-way to the anus, measured from their base (cf. the cod).

The pigment is everywhere dense except ventrally in front of the anus. Looking at the little fish from above, it is seen, that the whole of the dorsal aspect from the snout to the end of the tail is densely covered by black pigment. The sides are also densely and strongly pigmented right to the end of the tail. The mediolateral streak is well-marked and reaches forwards to about the beginning of D^2. In living specimens there is a faint yellow pigment on the neck and sides between the black spots, whilst the abdominal region has a silvery sheen.

The specimen of 30 mm. just described was taken, together with several other pelagic specimens, near the surface to the south of Iceland on July 19th, 1903, but young green cod of about the same size (from ca. 30 to ca. 50 mm.) are found generally in shallow water on the coasts of Iceland and the Færoes during the summer months. In contrast to the cod, the uniform, homogeneous pigmentation of the young green cod does not essentially change when they pass from the pelagic to the bottom-stages, so that the specimen described and figured might so far represent the young bottom-stage. To describe and figure the larger specimens of the green cod seems to me superfluous. This can easily be distinguished from the cod by the pigmentation, the position of the anus, the length of A^1 in comparison with A^2, the form of the caudal fin, the shortness of the snout, the size of the eyes and the lack of a long barbule, whilst on the other hand they are distinguished from the pollack of the same size, especially by: the position of the anus, the form of the tail, the length of A^1 in comparison with A^2 etc., in addition, by the number of rays in the two anal fins (see further, the description of the pollack and the figures of Pl. I). I shall only remark, therefore, that the black mediolateral streak, to judge at any rate from my specimens, is generally retained longer than in the pollack, whilst on the other hand the unpaired fins (likewise the caudal fin) do not become so extremely dark as in the pollack. When the fish have grown so large, that the lateral line is distinct, the two species are easily separated from one another by its form (arched in the pollack, straight in the green cod).

Material

Whole series of developmental stages, from the youngest postlarval to the bottom-stages, are sufficiently known through the "Thor"s material from Iceland and the Færoes, which contains many hundreds of pelagic specimens in addition to bottom-stages in thousands.

Verification of the determinations

This will be given later after the description of *G. pollachius*.

Occurrence within the region investigated

Pelagic post-larval young of the green cod are found in quantities in the coastal waters around the Færoes as well as south and west of Iceland, but unlike the cod not in quantities off the east and north of Iceland. In the North Sea also (58° 32′ N., 4° 18′ E.; April 30th, 1903 and many other places), the pelagic young of the green cod were taken on the voyage to Iceland.

The pelagic young of the green cod have not been found in the Danish waters within the Skaw.

3. *Gadus pollachius* Linné, pollack

Principal literature and figures:

Larval stages: Mc Intosh (1896, p. 171, pl. V), — Post-larval stages: undescribed. — Young stages: Mc Intosh & Masterman (1897, p. 272).

By the artificial fertilisation of the eggs belonging to this species, Mc Intosh succeeded in hatching some few larvæ, abnormal in appearance, which died however soon after hatching. Holt (1897—99) hatched out some eggs taken in the pelagic net in the neighbourhood of Plymouth and considered to be the eggs of pollack. The larva on hatching was 4·2 mm. long and had a single lateral row of black stellate chromatophores extending from the head over about one half of the length of the tail. Judging partly from the locality and partly from the similarity to Mc Intosh's larvæ, it is probable, that the larva mentioned by Holt is that of the pollack. The older larval stages are unfortunately unknown, so that we do not know the pigmentation and the remaining characters in these stages. Postlarval stages of the pollack have not been described; Mc Intosh (1896, p. 172) supposes they may resemble those of the green cod. Holt & Scott (1897—99, p. 156), who have published a very instructive and important list of the pelagic fish-eggs and larvæ observed at Plymouth in the year 1897, often mention here the young of *G. pollachius* of various sizes (e. g. 3·93 mm., 7 mm., 10 mm., 11—14 mm. etc. etc.); judging from the size, these are thus postlarval stages. No description of these specimens — often given with a? — is forthcoming, however, so that we cannot tell whether the authors have based their determinations otherwise than on the supposition, that around Plymouth there could be no question of the presence in quantities of other related species, as *G. virens* and *G. callarias*, which may well be the case in general.

The bottom-stages of *G. pollachius* seem to have been observed often by the British naturalists, who state that they occur in quantities in the shallow water at the coasts, in Scotland, for example, along with the young bottom-stages of the green cod and cod. Mc Intosh (1896, p. 172) thus mentions, that the young pollack from 28 to 43 mm. occur in quantities near the coast at the end of July. Concerning the determination of these stages of *G. pollachius*, Mc Intosh and Masterman (1897, p. 273) state: "In their earlier stages the young pollack are recognized by the great development of black pigment, the arch of the lateral line and the prominent mandible". These can scarcely be regarded, however, as quite the youngest bottom-stages; as in these the arch of the lateral line, which makes the older specimens so easily recognisable from the green cod, can not yet or but with difficulty be recognised.

I have not myself taken the pelagic young of *G. pollachius*, as the "Thor" has not worked within the spawning-region of this species. The following description is therefore based on material, which has come, partly from the Norwegian fisheries investigations, partly from the Marine Laboratory of Plymouth and the fisheries investigations in Ireland.

Description

3¾ mm. A quite young, post-larval specimen of this size from the Irish fisheries investigations may without doubt be referred to *G. pollachius*. It was taken on May 8th 1900 about 10 miles from Inisbofin Island (depth 20—60 fathoms).

The tail is quite symmetrical and there are no signs of developing rays or interspinous rays. The abdominal region is transparent showing the loose folds of the gut. The postanal pigment is very characteristic. As in the green cod, two bars (2 and 3) are present here, whilst the most posterior (1), which distinguishes the cod, is absent as in the green cod. In contrast to the latter, bar 2 extends very far back towards the end of the tail, and is, further, longer relative to bar 3 than is the case with the green cod (cf. Fig. 2, p. 13 with the accompanying Fig. 3). The bars end somewhat abruptly

both anteriorly and posteriorly, and are of a deep black. The interspace between 3 V and 2 V is greater than between 3 D and 2 D. In another specimen of about the same size from the west coast of Scotland 3 D and 2 D as well as 3 V and 2 V had already almost fused together.

On the neck are a few chromatophores, as also on the trunk over the abdominal region. There is a distinct streak of abdominal pigment within the abdominal cavity on its upper side. There are likewise some distinct preanal chromatophores.

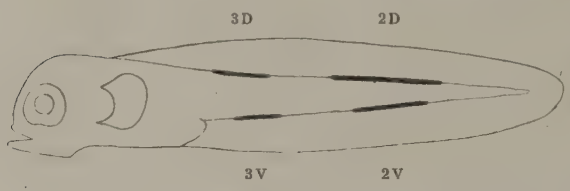

Fig. 3. Plan of the postanal pigment in the youngest postlarval stages of *G. pollachius*

Pl. I, Fig. 25 & 25 a

7½ mm. One specimen of this size is present, from southern Norway. It was taken on the 15th of June, 1904, at 5 meters depth in the Søndeled Fjord near Jæderen. It is a little broader and more robust than the cod and green cod of the same size, especially in the postanal region. The notochord is quite straight. There are distinct indications of the interspinous regions below and above in the caudal fin, where faint signs of rays are also seen. Further, indications of the interspinous regions occur in D^2 and D^3 as well as in A^1 and A^2 as low, opaque folds.

The pigment is very dense and of a deep black. The occipital spots are close together and very dark. This holds also for the preanal pigment, which consists of a conspicuous row of prominent chromatophores extending from the throat right to the anus. The abdominal pigment is also distinct. The postanal pigment no longer shows any trace of the arrangement into bars, the two dorsal portions of the bars having now fused together to form one very pronounced and dark dorsal streak, the two ventral to an equally well-marked ventral streak. A well-marked, continuous mediolateral streak is now present, extending anteriorly almost to the anus. Whilst the ventral streak reaches anteriorly to the anus, the dorsal streak is continued further forward, so that it joins on to the occipital pigment. All three streaks extend equally far back posteriorly and distinctly further than in *G. virens*, but as in the latter (in contrast to the condition in *G. callarias* and *G. saïda*) they end very abruptly, so that the short, pale termination of the tail stands out sharply against the remaining pigmented portion of the sides. Some black chromatophores are further equally distributed over these (without any lighter central part as in *G. virens*), and they have also a dark tinge, perhaps due to yellow chromatophores which have been distributed between the dorsal and ventral streaks in the living animal. This dark tinge extends posteriorly as far as the black pigment, and thus causes the pale termination of the tail to stand out even more sharply against the remaining portion. That the pigmentless portion at the end of the tail is so short, is important and of diagnostic significance (cf. *G. virens*).

In addition to the specimen mentioned there is another Norwegian specimen, which is slightly shorter but otherwise shows the same condition. It was taken on July 16th, 1904 at 62° 15 N, 2° 43′ E.

The following pelagic stages of *G. pollachius*, I have had the opportunity to examine, have come especially from the English Channel (neighbourhood of Plymouth) and were sent me by Dr. E. J. Allen. As they have lain in spirit since 1897, the pigment in some of them is but faint. Further, there are 2 specimens preserved in formalin in the Norwegian collection (length ca. 12 and ca. 15 mm.), The pigment here is very strong, stronger and denser than in *G. virens*.

Pl. I, Fig. 26

11¾ mm. The termination of the notochord is somewhat bent upwards. The length of its free portion is almost equal to ⅔—½ of the distance of its tip from the posterior border of the caudal fin. Rays are present in the greater part of the caudal fin with the exception of a narrow portion on both sides of the end of the notochord.

All the unpaired fins show indications of rays, which however are still very indistinct in D^1 which is extremely low. The developing rays in the middle portions of the anal and dorsal fins reach almost but not quite to the margin of the embryonic fin, which is still broad and fills the interspaces between the developing fins. The following rays could be counted; A^1 ca. 20, A^2 ca. 13, D^1 ca. 4, D^2 ca. 14, D^3 ca. 13. The caudal fin is broad and square posteriorly; its upper and under margins are strongly inclined upwards and downwards respectively. The pectoral fins are large and fan-shaped. The ventral fins can be clearly distinguished as somewhat lengthy and wart-like under the pectorals. The anus lies a considerable distance in front of the developing D^2 (in *G. virens* of this size it lies just in front of D^2). The length of the snout is greater than in *G. virens* and is flatter. The pigment is characteristic. There is no trace of the arrangement into bars. The dorsal streak is very distinct, likewise the continuous mediolateral streak, and both of these surpass the similar streaks of the cod and green cod in density, their chromatophores being placed exceedingly close together. The ventral streak is weaker than the two just mentioned. Posteriorly, the pigment streaks, which extend a little further back than in *G. virens*, end abruptly, so that the pigmentless, pale termination of the tail comes to stand out very sharply against the pigmented portion, especially as the latter has also a darker tinge (arising most probably from the yellow pigment), which is absent from the termination of the tail. The lighter part in the middle of the side between the original bars 2 and 3, which often in great degree characterises *G. virens*, is wanting here, the pigment being more evenly distributed. The dorsal streak is continued forwards, so that it reaches to the occipital pigment. In a Norwegian specimen of this size preserved in formalin there was a well-marked preanal streak.

15 mm.[1] The free end of the notochord is much more reduced than in the preceding stage, so that its length is only ca. $^1/_4$—$^1/_6$ of the distance from its posterior point to the border of the caudal fin. In the latter, there is no longer any portion free of rays. Pl. I, Fig. 27

The rays in the unpaired fins reach out to the margin. In A^1 there are 25—26, in A^2 16 rays, the posterior of which however are still but weak. The dorsal and anal fins are still surrounded by the embryonic fin, which is but low however opposite the interspaces. D^1 is very low but distinctly marked nevertheless. A^1 is much longer at its base than A^2. D^3 and A^2 are short but high, distinctly higher than in *G. virens*, which at the same size is on the whole further back as regards the development of the fins. The ventral fins are very short, but not pointed as in *G. virens*. The anus lies under D^1, far in front of D^2.

The pigment is quite as in the preceding stage but somewhat denser, and the short, pigmentless termination of the tail still stands out in sharp contrast to the remaining pigmented portion. In the specimens where the pigment is preserved, a well-marked preanal pigment streak is seen, extending from the throat to the anus.

16$^1/_2$ mm. The specimen to hand shows a distinct increase in bulk from the preceding stage, in addition to the increase in length. The unpaired fins, of which D^1 is still very low, are now almost quite separated. A^1 has 28, A^2 17 rays. In D^1 ca. 7 rays could be counted. D^3 and A^2 are relatively very high and much shorter at the base, than A^1. Strong, black chromatophores are present between the rays on a small part of the outer portion of the fin both in D^3 and A^2. The caudal fin is very broad posteriorly (relatively broader and shorter than in *G. callarias* and *virens*). The ventral fins are truncate and still very short. The anus is placed under the anterior third of D^1. The pigment is denser than in the preceding stages. Further, the postanal pigment extends posteriorly nearer to the end of the tail than in the preceding stage (and somewhat further back than in the green cod of the same size, though sometimes the differences are but small).

[1] Several specimens of about this size came from Plymouth.

Pl. I, Fig. 28 **18¼ mm.** The free end of the notochord is now quite reduced and difficult to see, even with high magnification. The little fish is distinctly broader, especially on the part behind the anus, than the cod or green cod of the same length, and it is also further forward in development both as regards fins and other characters. The unpaired fins are now quite separated. D^1 is distinctly lower than the other dorsal fins. The base of A^1 is much longer than the base of A^2. The caudal fin is exceedingly broad and its posterior border almost square. The anus lies under the anterior ⅓ of D^1. The ventral fins are short, but broad (not pointed as in *G. virens*). Their length is less than half the diameter of the eye, and they do not reach halfway to the anus, measured from their base. There are distinct pigment spots on all the dorsal and anal fins, chiefly on D^3 and A^2. The number of rays in A^1 is 30, and in A^2 17.

The pigment is exceedingly dense and pronounced, and covers almost the whole surface of the fish except the end of the tail. The chromatophores of the occipital pigment are situated very close to one another. There is considerable pigment also in front of the eyes. The preanal pigment consists of a distinct row of chromatophores extending from the throat to the anus Behind the anus there is a well-marked dorsal and also mediolateral streak, whilst the ventral streak is less well-marked anteriorly. The sides are quite covered over by densely packed chromatophores between these streaks, the chromatophores being quite uniformly distributed everywhere (no lighter [less pigmented] central part as in *G. virens*). The mediolateral streak extends forwards to opposite D^1. Posteriorly, the pigment extends a little beyond the beginning of the caudal fin, but a pale, pigmentless portion still remains at the end of the tail.

Pl. I, Fig. 29 **20¼ mm.**[1] The specimen to hand shows essentially the same characteristics as the one of 18¼ mm. The first dorsal fin is still low. The length of the ventral fins is now about equal to half the diameter of the eye, and they extend nearly halfway to the anus, measured from their base. The unpaired fins are pigmented like the previous specimen, yet there was no pigment on A^1. A^1 has 31–32, A^2 17 rays. The postanal pigment extends scarcely so far back as in the previous specimen, so that a slightly larger portion of the end of the tail is free of pigment. That the size at which the end of the tail becomes wholly covered by pigment may vary, is seen partly from Norwegian specimens (bottom-stages) of quite 18 mm., where practically the whole of the end of the tail is pigmented, partly from other (pelagic) specimens from Plymouth of quite 20 mm., where even a larger portion than in the specimen described and figured here is free of pigment. For the rest, the specimens from Plymouth and Norway show, that, at a length of ca. 23 mm., the whole or practially the whole of the end of the tail is always covered by pigment. At this size, the young pollack generally are already bottom-fish, which may be the case however at a length of 18—19 mm., and of the three species so far mentioned the present seems to have the shortest pelagic life.

Pl. I, Fig. 30 **32 mm.** The specimen to hand is a young bottom-stage taken on July 15th, 1904 in the Søndeled Fjord near Jæderen in Norway. D^1 is now higher than the other dorsal fins. The ventral fins reach more than halfway to the anus, measured from their base; they are ca. 2¼ mm. long or about as long as the diameter of the eye. All the dorsal and anal fins are strongly pigmented, much more so than in the cod and green cod, and it is characteristic, that the pigment is not diffusely spread over the whole fin, but densely congregated on each of these to a well-defined, circumscribed, deep black field, which covers the greater part of the fin and stands out in sharp contrast against their proximal as well as anterior and posterior portions, which are lacking in pigment (see the figure, Pl. I). The caudal fin, which is strongly pigmented near its base, is very broad and its posterior border is almost square. A^1, which has a much longer base than A^2, has 30, A^2 17 rays. The anus lies under the anterior third of D^1, and the distance from the tip of the snout to the anus is about equal to the distance of the latter from the centre of A^2. The form is shorter and thicker than in the cod and green cod of the same size.

[1] Several pelagic specimens of this size have been sent from Plymouth.

The trunk is thus distinctly deeper, both over the anus and more posteriorly. The length of the snout is greater than in the green cod, but scarcely so great as in the cod.

The pigment is very dense and dark, and extends right out to the end of the tail. The mediolateral streak is well-marked and reaches forwards to opposite D[1]. Looking at the fish from above, it is seen, that dense, continuous pigment extends right from the tip of the snout to the caudal fin. Ventrally, there is a distinct dark preanal row extending forwards right from the anus.

A more detailed description of the still older stages of *G. pollachius* seems to me superfluous. The same pigmentation is still retained for some time; yet, to judge from my material, the mediolateral streak often seems to disappear even at a length of ca. 4 cm, before therefore the permanent lateral line has become distinct. These specimens, in which the mediolateral streak has disappeared, may be recognised directly however from other *Gadus*-species, in which this streak is never developed, by the extremely great pigmentation of the unpaired fins, which is stronger also than in the cod, green cod or polar cod. Amongst these last three, it is strongest in the green cod, but not to the same extent on any of the fins, and especially not on the caudal fin, as in the pollack. For the rest, the two species are easily distinguished from one another by means of the characters given on page 16, and later, when the lateral line becomes distinct at a size of a little more than 4 cm., the separation is still easier.

Material

Most of the post-larval developmental stages and young bottom-stages are present in the material from Plymouth, Ireland and Norway, and this material shows, that the pollack is a well-defined species right from the stages of ca. 7 mm. in length, as figured on Pl. I, fig. 25. I have had too little material of the very youngest post-larval stages (before the appearance of the mediolateral streak), to be able to judge the extent of the variations and therewith determine, how far the species is always readily recognisable from allied species at this stage.

G. pollachius greatly resembles *G. virens*, the only species with which it may be confused. These are the only two of this group (with mediolateral streak) which have the pale terminal portion of the tail; but in *G. pollachius* this is a little shorter at all stages than in *G. virens*, which further is remarkable in these stages by having a lighter region centrally on the side. Further, in *G. pollachius* the postanal portion of the trunk is shorter and thicker, and the preanal streak of pigment is better-marked and longer (extending from in front right to the anus) than in *G. virens*. Lastly, the caudal fin is broader, the snout longer and the position of the anus further forward.

Verification of the determinations

The evidence that the stages of *G. pollachius* described really belong to this species, is closely connected with the corresponding evidence regarding *G. callarias* and *G. virens*.[1] I shall therefore consider them together here.

What has essentially contributed to simplify the separation of the three species is, that only two of them (*G. callarias* and *G. virens*) occur at Iceland, where the material was collected. On account of the isolated position of this island surrounded by deep oceans, we may conclude beforehand with almost absolute certainty that, if young post-larval stages of two species belonging to this group are found in quantities, they must consequently belong to the two species *G. callarias* and *G. virens*, which occur in quantities at Iceland. In this connection the investigations have been facilitated by the material coming

[1] Concerning the arctic species, polar cod (*Gadus saïda*), which also belongs to this group (with mediolateral streak), see the description of its developmental stages later. On account of its geographical distribution, it does not usually come into consideration and in all its stages also, it is so extremely slender and elongated, that it can be recognised at first glance from all the other species.

especially from Iceland and not from more southerly waters as the North Sea, where all three species occur; since, if we could distinguish with certainly all stages of the pelagic young of *G. callarias* and *virens* from one another, we could then turn with greater security to the investigation of collections from regions where *G. pollachius* also occurs, and in this way determine what are the special characteristics of this species. This is exactly the course I have followed: all the stages of *G. callarias* and *virens* were first of all distinguished with certainty by means of the material from Iceland, where only these two species occur, and *G. pollachius* was then determined from the material from more southern waters.

From the investigation of the young and older stages of the different *Gadus*-species I have come to the result, that of the various characters, which can readily be expressed numerically, the absolute number of the rays in the two anal fins on the one hand and the relation between the number of rays in the two fins on the other are of special importance. From an examination of the vertebræ in a very large number of specimens of the different species I have found, that the differences in the number of vertebræ are often so small that this method had to be given up. Nor do the paired fins show any greater differences and the anterior rays of the caudal fin are often difficult to count. The dorsal and anal fins still remain, and of these the latter hawe shown themselves to be best suited to giving characters which differentiate between the species. If we know the number of rays in A^1 and A^2 in a gadoid of this group, we may in most cases be able to decide whether we are dealing with the cod, green cod or pollack. It is therefore unnecessary in general to count the rays in other than the anal fins. I have counted the fin-rays in a number of cod and green cod at Iceland and obtained the results given below. Some of the enumerations published by WILLIAMSON (1902, p. 239—41), based on material from Scotland and including cod, green cod and pollack, are given at the same time, and further, some enumerations partly from the Great Belt, partly from Esbjerg which have been kindly placed at my disposal by the director of the Danish Biological Station, Dr. C. G. J. PETERSEN.

Gadus callarias

East Iceland (19 specimens)		Scotland WILLIAMSON (10 specimens)		Denmark: North Sea Esbjerg PETERSEN (25 specimens)		Denmark: Great Belt PETERSEN (75 specimens)	
Number of rays in	Number examined	Number of rays in	Number examined	Number of rays in	Number examined	Number of rays in	Number examined
A^1		A^1		A^1		A^1	
24		24	1	24		24	
23	1	23	1	23		23	1
22	2	22	3	22		22	4
21	3	21	4	21	3	21	12
20	3	20		20	8	20	25
19	7	19	1	19	6	19	19
18	2	18		18	4	18	7
17	1	17		17	3	17	6
16		16		16	1	16	1
A^2		A^2		A^2		A^2	
20	1	20		20		20	
19	6	19	2	19		19	4
18	6	18	4	18	10	18	13
17	1	17	4	17	11	17	31
16	5	16		16	4	16	21
15		15		15		15	5

Gadus virens

South Iceland (20 specimens)		WILLIAMSON's observations (18 specimens)	
Number of rays in	Number examined	Number of rays in	Number examined
A^1		A^1	
32		32	1
31		31	
30		30	2
29		29	
28	1	28	4
27	6	27	3
26	8	26	3
25	4	25	5
24		24	
23	1	23	
A^2		A^2	
24	2	24	1
23	2	23	4
22	9	22	5
21	4	21	6
20	3	20	2

Gadus pollachius

WILLIAMSON's observations (39 & 38 specimens)	
Number of rays in	Number examined
A^1	
34	1
33	2
32	
31	7
30	14
29	9
28	4
27	
26	1
25	1
A^2	
21	2
20	8
19	16
18	10
17	2
16	

On the basis of his observations, WILLIAMSON (l. c. p. 241) gives the following averages:

	A^1	A^2
Gadus callarias	21·6	17·8
Gadus virens	27·1	21·7
Gadus pollachius	29·7	18·9

In the principal ichthyological works of Krøyer, Day, Lilljeborg and Smitt only the highest and lowest number of rays in the various fins are usually given. The numbers I give below are partly from these works, partly those found by Williamson, C. G. J. Petersen and myself.

	G. callarias		*G. virens*		*G. pollachius*	
	A^1	A^2	A^1	A^2	A^1	A^2
Krøyer	17—23	16 -19	25—27	20—22	28—30	17—20
Day	17—19	16—18	24—27	20—23	24—31	16—21
Lilljeborg	18—20	15—18	23—29	20—23	24—32	16—21
Smitt	17—20	16—19	23—27	20—23	27—31	18—20
Williamson	19—24	17—19	25—32	20—24	25—34	17—21
Petersen	16—23	15—19				
Author	17—23	16—20	23—28	20—24		

Taking all these data into consideration, we have:

	A^1	A^2
G. callarias	16—24	15—20
G. virens	23—32	20—24
G. pollachius	24—34	16—21

From all these numbers we may draw the conclusion, amongst others, that any young *Gadus* of this group[1], which has attained the full number of rays, and which has less than 23 rays in A^1 is a cod (*G. callarias*). If it has more than 24 rays in A^1, it must be a green cod (*G. virens*), when A^2 has more than 21 rays, or put in another way: it must be a pollack (*G. pollachius*), when A^2 has fewer than 20 rays.

With the aid of these differences in the number of fin-rays in the three species, which can often be determined with certainty even at a length of ca. 20 mm, I have been able to verify the correctness of the determinations regarding the somewhat older, post-larval stages. The very rich Icelandic material, from amongst which *G. pollachius* as mentioned previously could be excluded beforehand, was first of all investigated, and it appeared therefrom, that 2 species with a mediolateral streak were present in quantities. On the one hand, a series of specimens was found, in which the postanal pigment was distinctly more developed than in the other species and ended abruptly posteriorly, so that a large and sharply marked portion at the end of the tail was pigmentless. On the other, a series of less strongly pigmented specimens occurred, in which the postanal pigment decreased uniformly in intensity and extended further towards the end of the tail; some black chromatophores were also found even at the end of the tail.

[1] With regard to the polar cod (*G. saïda*), which as mentioned on page 21 also belongs to this group (with mediolateral streak), see page 27.

One of the largest specimens with the pale terminal portion of the tail had 26 rays in A^1 and 22 in A^2, and consequently belonged to *G. virens* according to the tables given above. A somewhat smaller specimen (20 mm) with pale terminal portion of the tail had at least 25 rays in A^1 and at least 21 in A^2, a third of 20 mm had 25 in A^1 and 22 in A^2. In contrast to these, the following numbers were found in three specimens of 20—23 mm of the other series: $A^1 = 19$, $A^2 = 18$; $A^1 = 20$, $A^2 = 18$; $A^1 = 19$, $A^2 = 19$. One could thus conclude with certainty, that the first series must belong to *G. virens* and the second to *G. callarias*, so that *G. virens* as contrasted with *G. callarias* could be characterised by the pale, pigmentless terminal portion of the tail. This agrees extremely well also with what was known from the larval stages hatched out artificially, namely, that *G. callarias* has three postanal bars of pigment whereas the most posterior is lacking in *G. virens*[1]. Other characters for the separation of *G. virens* and *callarias* could also be found in specimens of about 20 mm in length, such as, the position of the anus with respect to D^1, the form of the caudal fin, the length of A^1 in relation to A^2, the size of the eye etc. etc., and it thus constantly appeared, that the series with the pale terminal portion of the tail agreed with *G. virens* in these characters, the other series with *G. callarias*. From the specimens of about 20 mm in length determined with certainty, continuous series were established down to the youngest post-larval stages. Some chosen representatives of these series have been described in the preceding pages and are figured on Plate I.

I am acquainted with the pelagic, post-larval young of *Gadus virens* from the Færoes and the North Sea in addition to Iceland. Further, I have examined specimens from Norway and the west coast of Ireland and always found, that the pigmentation affords a good means of distinguishing this species and *G. callarias*, even for the youngest post-larval stages where other characters can be used with difficulty.

G. pollachius. As already mentioned, the pelagic young of this species did not occur in the collections of the "Thor". In the collections of pelagic *Gadus*-young from Plymouth, on the other hand, there were some specimens (16½—21 mm long) belonging to the present main group (with mediolateral streak), in which the following number of rays was found: in some, $A^1 = 30$, $A^2 = 17$, in others, $A^1 = 31—32$, $A^2 = 17$, and again $A^1 = 30$, $A^2 = 17$. From these numbers it follows (see page 23), that the pelagic young in question belong to *G. pollachius*. As with *G. virens*, the younger specimens had the pale terminal portion of the tail, but the anus lay further forward, and the pigmentless portion of the tail was here a little shorter than in specimens of the green cod of the same size. In contrast to the green cod, also, a well-marked preanal streak was present.

I have referred the quite young, post-larval *Gadus*-young from Norway and Ireland described on pages 17—18 to this main group; firstly, because the oldest of them had a very well-marked mediolateral streak and the youngest one the arrangement of the pigment into bars, which is found in the other species of this group; secondly, because they differ considerably from the latter in pigmentation, and thirdly, because one can already discern how the dorsal, ventral (and mediolateral) pigment ends abruptly posteriorly, yet extends so far back, that the pigmentless portion of the end of the tail is but short.

4. *Gadus saida* Lepechin, **polar cod**

Principal literature and figures:

Larval stages: undescribed. – Post-larval stages: Ad. Jensen (1904, Pl. XI, Fig. 1). — Young stages: Ad. Jensen 1904, Pl. XII, Fig. 1).

Nothing was known concerning the developmental history of this peculiar species, until Ad. Jensen quite recently (1904) described 2 postlarval specimens of 13—16 mm in length and a large number of young stages, all from East Greenland, in his interesting work on the fishes of East Greenland.

[1] A further confirmation of the determinations is found in the fact, that only specimens with the pigmented terminal portion of the tail are found in the Danish waters inside the Skaw, where the cod alone of the two present species spawns, so far as known.

By reason of its distribution, which is for the most part restricted to purely arctic regions, it can as a rule be excluded from consideration, when collections of pelagic *Gadus*-young obtained for the purpose of fisheries investigations have to be determined.

My material consists partly of a number (10) of young post-larval stages, which I have taken east of Cape North (icel. Horn), the north-west headland of Iceland, partly of older postlarval and young bottom-stages originating from various Danish expeditions to East Greenland.

Description

6½ mm. Even at this stage, as in all older, the polar cod is remarkable for its extremely slender and elongated form, which causes it to be easily distinguished from all other species at the first glance. It is on the whole distinctly further back in development than other species at this size (thus, for example, the folds of the gut are still very loose and the abdominal region is transparent). The notochord is quite straight, and traces of developing interspinous rays are everywhere quite lacking in the embryonic fin. The occipital pigment is dense, consisting of large, stellate chromatophores. The abdominal streak is likewise well-marked. On the other hand, the preanal streak is quite lacking. The postanal pigment is very characteristic. It gives us the last example in this main group of how characteristic and important in systematic regard the bar-arrangement of the pigment can be. If we examine the little fish under high magnification against a white background (cf. p. 6), we find, that all three postanal bars (1, 2, 3) are present here just as in *G. callarias* (see Fig. 4). There is this difference, however, that the dorsal portions of the pigment are more strongly developed than the ventral portions, and this is the more decided because bar 1 (the posterior) usually consists of supernotochordal chromatophores only (1 D). 1 V is also fairly often present in other specimens. Pl. I, Fig. 19 and 19a

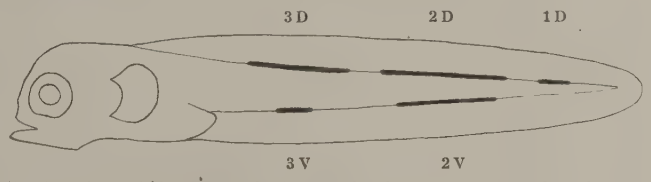

Fig. 4. Plan of the postanal pigment in the youngest post-larval stages of *Gadus saïda*.

1 D is here composed of 2 chromatophores. Bar 2 is very well-marked and in this respect surpasses bar 1. 2 D extends further back than 2 V. Between 2 D and 2 V as between 3 D and 3 V there is a single mediolateral, stellate chromatophore, the first indication of the mediolateral streak; 3 D is shorter than 2 D, yet very well-marked; on the other hand, 3 V is very weak (cf. the green cod, in which this is often the case also). Whilst 2 D and 3 D are in process of fusing together, 2 V and 3 V are still widely separated. On the dorsal ridge there is a row of chromatophores which connects 3 D with the occipital pigment. The pigment on the whole is stronger and a deeper black than in the cod, especially bar 2. As both the dorsal and ventral portions of all three postanal bars may occur, the polar cod is in regard to the pigment the most primitive species of this group.

8 mm. The notochord is quite straight. Indications of interspinous rays can just be detected now in the caudal fin as a slightly less transparent part without definite boundary on both sides of the notochord. Pl. I, Fig. 20

The pigment has not undergone any changes from the previous stage, except that there are now more mediolateral chromatophores. Thus, 3 V and 2 V are still quite separate. 1 D consists of 2 chromatophores, and further, 1 V is present here in the form of a single chromatophore.

9 mm. The notochord is quite straight, and the indications of interspinous rays are not yet well-defined. Only the dorsal portion of bar 1 is present. The original bar-arrangement can be recognised, though 3 V and 2 V are here also in process of fusing together. The mediolateral streak now consists of a larger number of chromatophores and is of considerable length.

Pl. I, Fig. 21 **11 mm.** The notochord is quite straight. The indications of interspinous rays in the caudal fin are now fairly distinctly defined above and below the notochord as folds, in which any divisions into separate interspinous rays cannot yet be detected. No signs of interspinous rays whatsoever can be seen in the dorsal and anal fins.

The pigment is more developed, but otherwise as before in the main. Bar 1 consists of 1 dorsal and 1 ventral chromatophore. The original bar-arrangement can easily be recognised ventrally, but only with difficulty dorsally. Posteriorly towards the end of the tail, 2 D and 2 V do not end abruptly (as is the case in *G. virens* and *pollachius*).

The mediolateral streak is well-marked and continuous. Preanal pigment is lacking.

Pl. I, Fig. 22 **13 mm.**[1] The notochord is quite straight. Distinct indications of rays are present above and below in the caudal fin, where however a large part centrally is still free of rays. Extremely weak signs of interspinous rays can be detected in the anal fins and the posterior dorsal fins; the pectorals are very large and fan-shaped; on the other hand, the ventral fins cannot be discerned. The eyes are of considerable size. The pigment has not essentially altered. The bar-arrangement cannot be recognised dorsally. Ventrally the first bar (3 V) is practically absent.

The chromatophores which compose the posterior bar (1) are small and faint in comparison with the remaining pigment, but yet distinct; both 1 D and 1 V are present, the latter being the weaker. The dorsal pigment is on the whole well-marked and the mediolateral streak distinct. The same holds for the occipital pigment. The dorsal streak is continued forward so that it joins on to the occipital pigment.

Pl. I, Fig. 23 **16 mm.** The notochord is quite straight. In the caudal fin ca. 17 developing rays can now be counted below, ca. 11 above, most of them being very distinct. A large part of the central portion of the fin however is still lacking in rays. Short but distinct indications of interspinous rays can be seen in the anal fins as in D^2 and D^3, where, however, they are further back in development than in the anal fins. It is only in A^1 that the first indications of some of the central rays are seen. The pectorals are very large and fan-shaped. The ventrals are not to be seen[2].

That the development of the rays in the fins is not further advanced at so considerable a size as 16 mm., is quite peculiar within the *Gadus*-genus and is evidently in relation to the fact, that *G. saïda* is the most arctic form of the present *Gadus*-species. We also find the same condition amongst the flat-fishes, as the arctic halibut (*Hippoglossus hippoglossoïdes*) reaches a much greater size than any other of the flat-fish-species investigated, before the rays develop. We are thus undoubtedly in sight of a biological characteristic of the arctic regions: viz. less advanced development at a relatively larger size than in the allied species of more southerly waters.

At this stage also, the polar cod is very obviously different from other species in having an extremely elongated form. The eyes are very large.

The pigment is practically the same as in the previous stage. Bar 1 is weak yet easy to discern. The dorsal portions of the two anterior bars are joined forming a continuous streak, and a similar streak is formed by the fusion of the two anterior ventral portions. Both streaks decrease gradually in strength posteriorly towards the tail. The dorsal streak is well-marked, the ventral streak is weaker, especially in front. The mediolateral streak is distinct and continuous. A preanal streak of pigment cannot be detected.

[1] This and the following specimens described come from various Danish expeditions to East Greenland and belong to the Zoological Museum in Copenhagen, which kindly gave them to me for investigation.

[2] As the specimen in question is somewhat damaged at the place where the ventrals are usually first seen, it is possible that the first signs of these fins have really been present.

There is now a jump in the developmental series, as the next specimen in the present material is 45 mm. long and no longer pelagic.

46 mm. A large number of specimens about this size are present, originating from the Danish expedition to East Greenland in 1900. The species they resemble most is the cod, but they are easily distinguished from this by the very elongated form, the larger eyes and the concave caudal fin. The anus lies under the anterior portion of D^2. A^1 and A^2 have about the same length at the base. In one specimen examined there where 19 rays in A^1 and 20 in A^2. It is characteristic, that A^1 extends considerably further back than D^2. The outermost rays of the ventrals are prolonged and reach almost to the anus. The dorsal and anal fins are tolerably well-pigmented, especially the first. The caudal fin is also pigmented. The pigment of the trunk is dense and strong, and a fairly distinct mediolateral streak is present in most of the specimens. The pigment differs from that of *Gadus callarias* by the lack of the chequered grouping. Pl. I, Fig. 24

Older stages are present in considerable number, but there is no call to enter further upon a description of their appearance.

Material

Whilst the younger, post-larval forms up to a length of 16 mm. are very well-represented, there is then a gap in the series to 45 mm. The intermediate stages will undoubtedly be easily recognised, amongst other things, by the extremely elongated form, the mediolateral streak, the pigmented end of the tail and the slow development of the fins.

Verification of the determinations

The young stages of nearly 5 cm. in length, present in quantities from East Greenland, may readily be referred to *G. saïda* on account of many characters. Amongst these, by way of example, may be mentioned the number of rays in the anal fins, where the characteristic condition occurs, that A^1 has most often fewer rays than A^2. Ad. Jensen (1904, 268) thus gives the following number of rays for 6 East Greenland specimens:

A^1	A^2	A^1	A^2
18	20	19	20
17	19	19	21
18	19	18	22

Lilljeborg (1891, p. 103) gives A^1 16—19, A^2 19—23 rays, and Smitt in "Skandinaviens Fiskar" (1892, p. 485) gives 15—19 rays in A^1 and 19—22 in A^2. In two Icelandic specimens I have found the following numbers:

A^1	A^2
17	21
18	22

That A^1 should have fewer rays than A^2 is almost unique in the *Gadus*-genus, and this feature thus offers an excellent diagnostic character. By means of this and several others, as position of the anus, form of the caudal fin, size of the eyes, the East Greenlandic young stages (about 5 cm. in length) have thus been determined as *G. saïda*, and it was determined at the same time, that the mediolateral streak also appears in this species[1]. If it is sometimes but weak, that only means, that it is about

[1] The presence of a mediolateral streak in this species has, however, already been described and figured by Ad. Jensen, with regard to the postlarval stages described by him (1904, p. 269, pl. XI, fig. 1). But this author does not mention, that it is also found in the young stages, which is however of importance for the determinations of the early stages.

to disappear at this size, just as may be the case in other species of this group (*Gadus pollachius*, *virens* and *callarias*), when they have reached a length of nearly 5 cm.

After it had been determined, that *Gadus saïda* has a mediolateral streak, and thus belongs to the first group of *Gadus*-species, and after the appearance of the other species of this group was known, the post-larval *Gadus*-young with mediolateral streak above-described from Iceland and East Greenland could only be referred to *G. saïda*, with whose older stages they also agreed in their extremely elongated form.

Occurrence within the region investigated

Within the region investigated by the "Thor", the pelagic young of *G. saïda* have only been taken at Iceland, and in all the hundreds of hauls with the young-fish-trawl, which were made round Iceland in 1903 and 1904, there was only a single one (east of Cape North early in July 1903) which contained *G. saïda*. The polar cod is far from common at Iceland, which is on the whole one of the least arctic of the regions in which it occurs. I have taken here and there at East and West Iceland some quite isolated, older specimens of this species along with the common cod (*G. callarias*): in the two years but 5 specimens in all amongst hundreds of thousands of the common cod.

In the work cited, on the fishes of East Greenland by Ad. Jensen, the observations are given of various travellers to the polar regions (p. 267—268) with reference to the biology of the polar cod. Thus, the reports of all observers show, that it occurs amongst the floes of polar ice as well as at the coasts. It has been found swimming around floes of drift ice even over very great depths far from the coasts. The late Danish zoologist, Søren Jensen, who took part in the Danish expedition to East Greenland in 1900 and had often observed the polar cod amongst and close to the ice-floes, has put forward the view, that we see here a peculiar occurrence of littoral, arctic animals (various amphipods etc. in addition to the polar cod), which follow the drift-ice out to sea, but do not really lead any true pelagic life, as they keep to the ice-floes. According to Søren Jensen's observations, they keep to the foot of the ice, between this and the ice-floes and find there similar conditions of life as at the coasts of arctic lands, where they truly belong.

I have mentioned these observations here, because they seem to me of interest and able to throw light upon the sporadic occurrence of the polar cod at Iceland, where the drift-ice is accustomed to appear every year. The part of Iceland, which is usually and in special degree visited by the drift-ice, is the stretch of coast near the north-western promontory, Cape North (icel. Horn). It was in the neighbourhood of this, in the Huna Bay, that the single haul with the young-fish-trawl, which gave the pelagic young of *Gadus saïda*, was made early in July 1903, when the ice had lain close up to the coast for a long time. Later on in 1903 and in 1904, the young were not found in the many hauls round Iceland, and it may be added, that in 1904 I specially sought for them round Cape North, in the neighbourhood of which, however, there had been no ice during the whole summer of that year.

On the mediolateral streak and pigment bars in the species of the first main group (*G. saïda, callarias, virens* and *pollachius*)

What specially characterises and unites the species in the first main group above-described, is the occurrence of the mediolateral streak, all trace of which is quite lacking in the following 6 *Gadus*-species. It is certainly not yet present in the larval and earliest post-larval stages, but even these stages show a characteristic, by means of which the four species mentioned are neatly joined together in contrast to the following six, which compose the second main group. This character lies in the grouping of

the postanal pigment into distinctly marked transverse bars, of which there are typically three, each consisting of a dorsal and a ventral portion.

The typical condition may be taken to be represented in Fig. 5, where the dorsal and ventral portions of all three bars (1, 2, 3) are present and equally well-developed. In reality, however, either the dorsal portions are more strongly developed than the ventral portions or *vice versa*. The polar cod (*G. saïda*, Fig. 6) comes nearest the type with all three bars, and in it both the dorsal and the ventral portions of bar 1 (the posterior) may be present. The rule seems to be, however, that only the dorsal portion is found, or in any case is the strongest, which is in agreement with the fact, that the dorsal portion of the pigment is on the whole more strongly developed than the ventral.

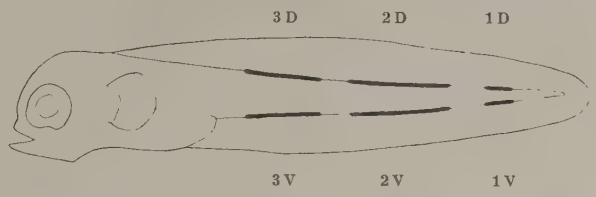

Fig. 5. Plan of the typical form, from which the postanal pigmentation in the first main group of *Gadus*-species may be deduced.

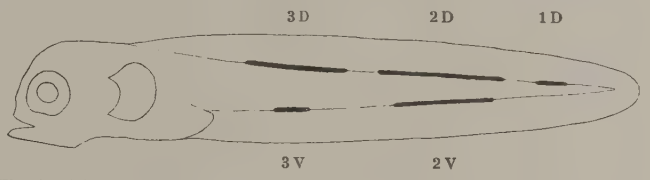

Fig. 6. Plan of the postanal pigment in the youngest postlarval stages of *G. saïda*.

Then comes the cod (*G. callarias*), which also has all three bars, but in it the ventral portions are as rule more developed than the dorsal. Thus, of bar 1 only the ventral portion is here present (see Fig. 7).

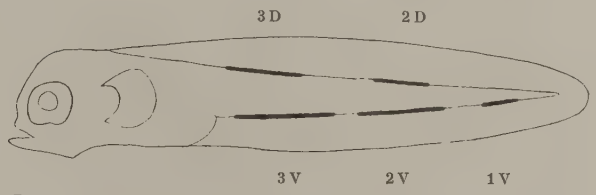

Fig. 7. Plan of the postanal pigment in the youngest postlarval stages of *G. callarias*.

Lastly, we have the green cod (*G. virens*) and the pollack (*G. pollachius*), in which the posterior bar is quite lacking (see Fig. 8—9), and which in this regard stand further from the type. In both, the dorsal pigment is more strongly developed than the ventral, especially in the green cod, which is also especially distinguished from the pollack by having bar 2 distinctly shorter, so that the pigmentless portion of the tail is thus much longer (see Fig. 8, 9).

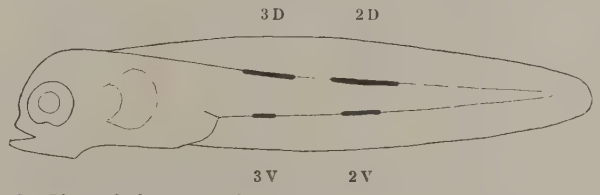

Fig. 8. Plan of the postanal pigment in the youngest postlarval stages of *G. virens*.

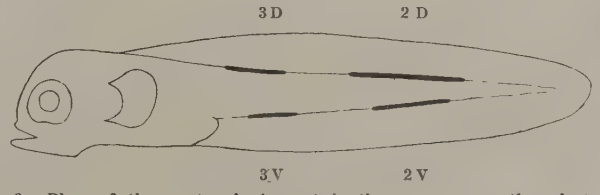

Fig. 9. Plan of the postanal pigment in the youngest postlarval stages of *G. pollachius*.

The only newly hatched larval stages known to me are those of the cod (*G. callarias*) and green cod (*G. virens*). I have hatched out a large number of eggs of both these species on board the "Thor" at Iceland in April 1904, and could thus determine, that even in the youngest larval stages they are easily distinguishable from one another by means of the pigmentation. When the cod-larva leaves the egg, the pigment has in general already become distinctly grouped into the there transverse bars (cf. the figure in Mc Intosh and Masterman, 1897, Pl. IX, Fig. 1) and the eyes are generally deep black. On the other hand, the pigment of the green cod on hatching is more diffuse and weaker, and the eyes are pigmentless. Only some time

after hatching does the pigment collect into the two postanal bars (the third is lacking) and the eyes assume pigment, so that they become quite black.

In this connection the difference between the cod and green cod can be expressed as follows: the green cod generally leaves the egg at an earlier stage of development than the cod, which can generally be recognised even in the egg from its black eyes and the arrangement of the pigment into bars. For the rest, the cod is also larger than the green cod on hatching; both species lack yellow pigment in the larval stages. The larvæ of the green cod have already been well represented and described by Mc Intosh (1894, pl. II and pl. III, Fig. 1—5), who has not however called attention in any special degree to the lack of the posterior pigment bar.

We have now seen, therefore, that the species of the first main group, even from the earliest stages, are grouped together naturally and are characterised, as contrasted with the other *Gadus*-species, by the grouping of the postanal pigment into three bars typically, the posterior of which may be wanting[1], and especially by the occurrence of a mediolateral pigment-streak. If we study the composition of the first main group, whose species have been placed together according to the pigment from purely practical diagnostic reasons, we see, that it is in reality the naturally allied and mutually more nearly related species of the *Gadus*-genus, which compose this group[2] (consisting of *G. saïda, G. callarias, G. virens* and *G. pollachius*). This shows, that the pigmentation in the postlarval stages of the *Gadus*-genus has a systematic value, and it is of great interest to etablish this in this work, which to an essential degree has been obliged to seek for differentiating characters in the pigment.

For the rest, the *Gadus*-genus is not the only example of how the species within a genus can be divided into groups according to the pigmentation of the youngest stages. Something similar has been shown by Petersen (1904, p. 4) for the genus *Pleuronectes*, whose species are thus divided into two groups. In one of these, consisting of plaice (*Pl. platessa*), dab (*Pl. limanda*) and flounder (*Pl. flesus*), the youngest stages lack the bar-arrangement of the postanal pigment, which is present in the second group consisting of the witch (*Pl. cynoglossus*) and lemon dab (*Pl. microcephalus*). Future working out of the material of pelagic young of fishes from Iceland and the Færoes will furnish further examples of the diagnostic and systematic importance of the pigmentation in the youngest stages.

II. Main Group (mediolateral streak wanting)

To this main group belong the haddock (*G. aeglefinus*), whiting (*G. merlangus*), Norway pout (*G. Esmarki*). poor cod (*G. minutus*), the pout (*G. luscus*) and the poutassou (*G. Poutassou*). The group is sharply distinguished from the first, in that there is never any trace of the mediolateral streak, and in that the pigment of the youngest postlarval stages is not collected into 3 (or 2) transverse bars, which can be deduced from the type represented in Fig. 5.

For the purposes of a summary, this group can be divided into two smaller subgroups according to the condition of the postanal pigment in the early postlarval stages. In one of these, the pigment (ventral and dorsal rows) ends very abruptly at a considerable distance in front of the

[1] Amongst the species of the second main group, *Gadus Poutassou* (and *Gadus luscus*) show a kind of bar-arrangement (see text-figure 16) of the postanal pigment, but only one bar is present here, whose position and appearance does not permit it to be brought into agreement with the type from which the species of the first main group can be deduced.

[2] Within this group *G. virens* and *pollachius* are respectively the most nearly allied according to the pigmentation, which holds also for most of the other characters.

termination of the tail, which thus remains quite pigmentless (cf. green cod [*G. virens*] and pollack [*G. pollachius*]), so that it stands in sharp contrast to the remaining pigmented portion of the body.

In the other subgroup, which contains the most of the species as well as the most important, the postanal pigment especially the ventral portion decreases gradually towards the tail, the posterior chromatophores being placed further from one another than the anterior; further, the ventral portion at least reaches almost to the end of the tail. There is thus not the contrast between the end of the tail and the remaining portion of the body as in the first-mentioned subdivision. (Compare e. g. the text-figures 11 and 16 or figures 1 and 20 of Pl. III.)

The subdivision of the six species according to this feature thus comes to be as follows:

1st Subgroup

Neither in the younger nor in the older postlarval stages does the ventral pigment (or the postanal pigment taken on the whole) stop abruptly some distance from the end of the tail, but on the contrary continues almost right to the end, decreasing gradually in strength.

5. *Gadus aeglefinus* Linné
6. *Gadus merlangus* Linné
7. *Gadus Esmarki* Nilsson
8. *Gadus minutus* O. F. Müller

2nd Subgroup

In the younger postlarval stages the postanal pigment ends abruptly a considerable distance from the end of the tail, which is thus pigmentless (pale) and therefore stands in sharp contrast to the pigmented portion of the body.

9. *Gadus luscus* Linné
10. *Gadus Poutassou* (Risso)

1st Subgroup (end of the tail not pigmentless)

5. *Gadus aeglefinus* Linné, haddock

Principal literature and figures:

Larval stages: Cunningham (1887, pl. VI, fig. 1)?; Mc Intosh & Prince (1889, pl. XVII, fig. 1); Holt (1891, pl. VI, fig. 48—49); Hensen & Apstein (1897, pl. III, fig. 23); Heincke & Ehrenbaum (1900, pl. IX, fig. 14). — Postlarval stages: Mc Intosh (1897, no figures). — Young stages: Mc Intosh (1897, pl. V).

Whilst the larval stages of the haddock are well-known and have often been figured (Holt's figures especially are good), this is not the case with regard to the postlarval stages. What we know of the latter, is due chiefly to Mc Intosh (1897) who has given characteristic figures of the older pelagic stages and also describes the young, without giving figures however.

The extremely rich material of pelagic haddock-young at all stages from the newly escaped larva on, I have taken at Iceland, shows, that this species is very clearly characterised at all stages and easy to distinguish from the remaining *Gadus*-species.

Description

4 1/5 mm. (See figure 10 in text.) There are no indications whatsoever of interspinous rays or fin-rays. The embryonic rays are specially distinct in the caudal part of the marginal fin. The pectorals

are large, fan-shaped folds. The end of the gut has not yet reached the margin of the embryonic fin. The preanal portion of the body is very short and thick. The eyes are large and deep black.

The pigmentation is characteristic. The occipital pigment consists of a few stellate chromatophores. The abdominal pigment is very strongly developed and covers the greater part of the lateral portions of the gut. The preanal pigment (ventrally) is lacking. The anterodorsal pigment is very pronounced and consists of a collection of large stellate chromatophores on the shoulder over the pectorals, extending forwards almost to the neck and posteriorly some distance in front of the anus. Further back there is no dorsal pigment or at most a single isolated chromatophore. The lateral aspects of the tail are also practically void of pigment; sometimes however a few, scattered, lateral chromatophores may appear. The ventral pigment consists of a row of tolerably closely placed chromatophores, which extend from a short distance behind the anus to near the end of the tail. The most posterior (or several) of these chromatophores is often separated from the next in front by a little larger interspace than usual. For the rest, the ventral chromatophores, all of which are not entirely superficial, vary in intensity, so that in some specimens they are obvious, in others weaker.

Fig. 10. *Gadus aeglefinus*. Young, postlarval stage. Hatched on board the "Thor" at the end of May 1904 at South Iceland. Natural size: 4 1/5 mm.

The specimen described was hatched on board the "Thor" from an artificially fertilised egg of the haddock. The smallest stages found in the sea at Iceland measured ca. 4 1/2 mm. and were already easily recognisable from the pigmentation and the plump, short preanal region. They resembled the specimen described in every respect.

Pl. II, Fig. 10 **6 3/4 mm.** The characteristic plump form, which arises from the shortness and thickness of the head and preanal portion of the trunk, is very apparent. The end of the notochord is quite straight, and the embryonic fin, which reaches forward to in front of the eye, is broad.

There are faint signs of interspinous rays underneath and above in the caudal fin, but no traces of rays as yet. The pectorals are fan-shaped folds with embryonic rays, and the first indications of the ventrals have not yet appeared.

The occipital pigment consists of a considerable number of large, round chromatophores. These are continued posteriorly in a dorsal double row reaching a little further back than the posterior margin of the pectorals; in the prolongation of this dorsal row there are some quite faint chromatophores, which extend posteriorly to a little beyond the anus. Further back still, the dorsal pigment is practically wanting, though a few faint points may sometimes occur very far back. The dorsal pigment is thus essentially limited to the part over the pectorals. The abdominal pigment is well-developed, but the preanal pigment on the other hand is practically absent. The ventral pigment is also distinct as a row of small, fairly definite spots, which extends from the anus to the hypural elements in the caudal fin.

In living specimens of this size there is a little yellowish brown pigment on the neck and abdominal region, and, somewhat fainter still, along the anterodorsal streak. Behind the anus there is no coloured pigment.

Pl. II, Fig. 11 **9 mm.** The plump form of the trunk in front of the anus is still very apparent. The end of the notochord is quite straight. Embryonic rays are present in the greater part of the caudal fin; but both below and above, however, faint indications of true rays are to be seen. The interspinous regions

in the anal and dorsal fins are indicated by very low folds. The pectorals have embryonic rays and are lacking in pigment like the other fins, the ventral fins are now forming as quite small wart-like processes.

The occipital and abdominal pigments are both well-developed, but otherwise as previously; the preanal pigment is very weak, consisting of ca. 5 small points placed at some distance from one another. Behind the occipital pigment dorsally, there is a portion free of pigment or less pigmented, followed by the dorsal pigment which extends to a little distance behind the anus, giving off above the latter a small side branch of dorsolateral chromatophores (cf. fig. 12, pl. 2). Further back, pigment is lacking dorsally. The postanal ventral pigment consists of a row of small round chromatophores, which are not very apparent and are in part below the surface.

10 mm. The preanal portion of the trunk is still very plump. The end of the notochord is a little bent upwards. There are distinct indications of rays below and above in the caudal fin, but a large part on both sides of the end of the notochord is still lacking in rays. Indications of rays can now be seen in all the unpaired fins; they are most apparent in A^1 and D^2. The pectorals are large fan-shaped folds with faint indications of rays, but with very strongly marked pigmentation, consisting of radiating, stellate chromatophores[1]. The ventrals are pigmentless, but already relatively long, though scarcely so long as half the diameter of the eye.

The pigment is essentially as in the previous stage. Only the occipital, abdominal and anterodorsal pigments are well-developed, the last reaching posteriorly to a little distance beyond the anus. The ventral row consists of a few chromatophores somewhat distant from one another, whilst the pigment laterally and posterodorsally is quite wanting. In living specimens there was a yellowish brown pigment on the neck and back, where it extends as far back as the black anterodorsal pigment. Behind this there is no coloured pigment.

11¼ mm. The free end of the notochord is somewhat bent upwards; its length is about ⅓ of the distance from its end to the posterior margin of the caudal fin. There is now only a small part remaining in the caudal fin which is free of rays; and very distinct indications of rays are present in all the unpaired fins (also in D^1), and there are strong, black pigment spots between the rays in the first two dorsal fins. The following number of tolerably distinct rays could be counted: D^1 ca. 6, D^2 ca. 10 and D^3 ca. 10 (weaker), A^1 ca. 12 (weaker), A^2 ca. 7. The developing rays are still far from reaching out to the margin of the broad embryonic fin. Both pectorals and ventrals have distinct rays in process of development. As in the previous stage the pectorals are densely pigmented by many chromatophores, which are arranged radially between the rays. The ventrals are about half as long as the diameter of the eye, and especially towards the end covered by well-marked, black chromatophores between the rays. The anus is placed under the anterior half of D^2. Pl. II, Fig. 12

The pigment of the trunk and sides is essentially as before, but more developed. The great development of the anterodorsal pigment is still remarkable; from it a dorsolateral branch runs out almost opposite the beginning of D^2.

13½ mm. The length of the free end of the notochord is about ⅓ of the distance from its posterior point to the posterior margin of the caudal fin. A narrow part of the caudal fin is still lacking in rays. Indications of rays are distinct in all the unpaired fins, but pigment is only present in D^2 and especially D^1. Both the pectorals and ventrals are pigmented. The length of the latter is now about ¾ of the diameter of the eye; they are strongly pigmented especially towards the end.

[1] In other specimens of this size the pigmentation was still, however, much less developed.

The anterodorsal and anterodorsolateral pigments are still very distinct and constant in their occurrence, as also the occipital and abdominal pigment. The ventral pigment consists of a few, isolated, weaker or stronger chromatophores. Posterodorsal pigment is absent. Scattered chromatophores may on the other hand appear irregularly distributed over the sides; they are but little constant and partly under the surface.

Pl. II, Fig. 13 & 13a

15 mm. The free end of the notochord is strongly bent upwards, and its length is now only ca. $^1/_5$ of the distance from its posterior point to the margin of the caudal fin (it is too strongly represented in Fig. 13, Pl. II). There is no longer any part of the caudal fin free of rays. The unpaired fins are still bound by the broad embryonic fin; but the central rays in the developing fins now reach out to the margin. The following number of developing fin-rays was found: D^1 ca. 8, D^2 ca. 15, D^3 ca. 16, A^1 ca. 14, A^2 ca. 14. There is pigment now in D^1, D^2 and A^1. D^1 is relatively very high and the most pigmented of the unpaired fins. The pectorals are large, well-pigmented folds. The length of the ventrals is at least $^3/_4$ of the diameter of the eye; they are strongly pigmented towards the tip.

The figures 13 and 13a of Pl. II show, that the occipital and abdominal pigments are very strongly developed and dense. The same holds for the anterodorsal and anterodorsolateral pigment, in part also for the ventral row, which however may be much weaker in other specimens. Posterodorsal pigment is quite wanting. Of importance is the anterodorsolateral side-branch, which is seen behind the pectorals, as it forms the point of departure for a great part of the pigment of the following stages[1].

Pl. II, Fig. 14

19 mm. The volume of the little fish has increased in marked degree from the preceding stage. The plumpness of the preanal portion of the trunk is still very apparent. The free end of the notochord is almost entirely reduced. The unpaired fins are not yet entirely separated, a small portion of the embryonic fin remaining opposite the interspaces. With exception of D^1 they have already assumed essentially their permanent form. In A^1 there were ca. 21, in A^2 ca. 19 rays, of which the posterior are still a little indistinct. The lengths of the bases of the two fins are but little different. Pigment is present between the rays in A^1 and D^2, but especially in D^1. In the caudal fin also, there are some single, but very weak chromatophores. The pectorals are very broad and large; they reach a little distance behind the anterior portion of D^2 and have deep black pigment. The ventrals are also well-pigmented; their length is ca. 3 mm. or considerably larger than the diameter of the eye, and they reach more than halfway to the anus. This lies under the beginning of D^2. With regard to the pigment, the anterodorsal and the anterodorsolateral are specially apparent as well as the occipital; the anterodorsolateral is in process of spreading out posteriorly. No pigment is present posterodorsally. The ventral row is not very obvious. In other specimens, however, there is also more pigment on the sides posteriorly.

Pl. II, Fig. 15

25 mm. The form has not essentially changed, yet perhaps a trifle less plump. The corners of the caudal fin are rounded off and its posterior border is almost straight. The unpaired fins are entirely separated and D^1 is considerably higher than before. In A^1 there were 21, in A^3 22 rays. In all three dorsal fins (especially D^1) and in A^1 there is black pigment. Both pectorals and ventrals are strongly pigmented. The latter are ca. 4 mm. long, but still scarcely reach to the anus. This is placed under the anterior portion of D^2. With exception of the mediolateral part, the greater portion of the sides is strewn with pigment.

Pl. II, Fig. 16

29 mm. The preanal portion of the trunk is still very plump, but the greatest height, which is at about the beginning of D^1, is placed a little further back than in the preceding stage. Pigment is present on the unpaired fins with exception of A^2, but the caudal fin has only some single fine spots.

[1] In Fig. 13a of Pl. II, which represents the animal seen from above, the gill-covers are unnaturally wide open.

The pectorals and ventrals are also pigmented, the latter being ca. 5 mm. long and reaching quite to the anus[1]. In A^1 were 24, in A^2 23 rays.

The pigment is diffuse but tolerably weak; the anterodorsal (and anterodorsolateral) portion is the strongest.

43 mm. The form is considerably less plump than in the specimen last described, and in this regard approaches more to the adult haddock, which also holds good for the form of the fins. Pigment is present in D^1, D^2 and D^3 and A^1, in the caudal fin and in the unpaired fins. In A^1 there were 24, in A^2 23 rays. The ventrals reach to the beginning of A^1. Their length is barely 8 mm. The pigment on the sides is dense. Just as is often the case in older *Gadus*-young, there are some collections of dorsolateral pigment, their number here being three. The most anterior of these (under D^1) is the strongest developed, and from it is developed the peculiar dark spot, which characterises the haddock to such a high degree. Pl. II, Fig. 17

There is no need to describe the stages still older than the one mentioned of 43 mm., which was taken near the bottom at South Iceland in July, as they can be easily recognised from all other species of this main group by the position of the anus under the anterior portion of D^2, by the pigmented pectoral and ventral fins, by the high D^1 etc.

At a length of ca. 5 cm. the small haddock generally seek the bottom at Iceland, but, like the cod, they may however be found pelagic up to a very considerable length (ca. 10 cm.). In contrast to the cod and green cod, they do not occur on the shallowest waters at the coasts, and their pelagic life is for the rest of longer duration than in these two species.

Material

The material from Iceland contains several thousands of pelagic young haddock in all stages and shows the whole developmental history very perfectly.

Verification of the determinations

This has been carried out on the Icelandic material, partly by use of the hatching method, partly by means of series. The following species of this main group occur at Iceland: haddock (*G. aeglefinus*), whiting (*G. merlangus*), Norway pout (*G. Esmarki*) and poutassou (*G. Poutassou*). Whilst the first three are extremely common, the last seems to be at least less common than the others, though it is by no means rare. The two species, pout (*G. luscus*) and poor cod (*G. minutus*) have not been found at Iceland, neither previously nor during the "Thor"s fishery investigations round the island (see however later, page 57).

The haddock is perhaps the commonest of the species named; during the investigations of the "Thor" in 1903 and 1904, it was found to spawn in enormous quantities at South Iceland, and after the cod it is the principal species in the fisheries of the Icelanders. We should expect beforehand, therefore, to find its pelagic young in quantities at Iceland. I give below the number of rays in the anal fins and D^2 in the species of this main group, which occur at Iceland, according to the principal ichthyological works mentioned earlier (for the other species, see page 53).

[1] Mc Intosh (1897, pl. V, Fig. 5) figures a young haddock of 29 mm., in which the ventrals reach almost to the end of A^1 (yet not in fig. 2 of the same plate, which is supposed to represent the same specimen as fig. 5). I have never seen ventral fins so long as this in the haddock.

	G. aeglefinus			*G. merlangus*			*G. Esmarki*			*G. Poutassou*		
	A^1	A^2	D^2	A^1	A^2	D^2	A^1	A^2	D^2	A^1	A^2	D^2
Krøyer	23—26	20—25	20—23	33—34	21—24	19—23						
Day	24—25	20—22	20—24	30—35	20—24	18—23				34—38	20—25	12—14
Lilljeborg	23—27	20—24	20—24	30—35	20—25	18—23	27—30	24—26	22—25	36—41	24—27	12—14
Smitt	21—25	20—21	20—24	31—38	20—24	20—25	26—30	24—28	23—26	34—39	23—25	12—14

If we take all these into consideration as well as the numbers given later, p. 45 note, we obtain the following:

	A^1	A^2	D^2
G. aeglefinus	21—27	20—25	20—24
G merlangus	30—38	20—25	18—25
G. Esmarki	26—30	24—30	22—26
G. Poutassou	34—41	20—27	12—14

We see from this and from the numbers given on page 53, that a young *Gadus* of this main group, which has attained its full number of fin-rays and has fewer than 25 rays in A^1, must be a haddock (*G. aeglefinus*).

In the material of pelagic *Gadus*-young taken at Iceland, one species occurred in quantities which was very striking and easy to distinguish from the remaining species by its plump form and lack of mediolateral streak. In 3 older specimens of a little over 20 mm. in length, the following number of fin-rays was found: A^1 21, A^2 22; A^1 23, A^2 22; A^1 24, A^2 23. This was sufficient proof that they belonged to *G. aeglefinus*, which further appeared from the position of the anus under the anterior half of D^1, all the other species of this main group having the anus further forward under D^1. The strong pigmentation of the ventral and pectoral fins was characteristic, and the length of the former was also striking. The most strongly developed pigment was the anterodorsal and the anterodorsolateral.

Series of this plump species of *Gadus*, the larger specimens ot which of ca. 20 mm. could already be determined with certainty as *G. aeglefinus*, were easily established by paying attention to the characters mentioned. A developmental series was thus obtained, whose youngest unit was quite identical with the youngest postlarval stages artificially reared from the haddock-egg, and in which both the plump form of the anterior portion of the trunk as well as the strong development of the anterodorsal pigment had already been found to be characteristic. By means of all these data, it was determined, that the Icelandic series of plump *Gadus*-young, chosen specimens of which have been described above and figured on Plate II, really belonged to the haddock.

Occurrence within the region under investigation

Large numbers of the pelagic young of haddock were found during the spawning-time off South and West Iceland, and also later in the summer off North Iceland. I have found them also at the Færoes, in the North Sea, Skager Rak and the most northerly Kattegat.

In the Danish waters within the Skaw, the pelagic young of haddock occur only in the northern parts of the Kattegat.

6. *Gadus merlangus* Linné, whiting

Principal literature and figures:

Larval stages: Mc Intosh & Prince (1889, p. 825, pl. XVI, fig. 2); Heincke & Ehrenbaum (1900, pl. IX, fig. 7—13). — Postlarval stages: Mc Intosh & Prince (1889, p. 8, pl. XVII, fig. 12); Mc Intosh (1897, p. 201, pl. VI); Masterman (1900, p. 9, pl. III).

Larval stages undoubtedly belonging to this species were first described and figured by Mc Intosh & Prince (1889, pl. XVI, fig. 2) from specimens reared from artificially fertilised eggs; later also by Heincke and Ehrenbaum. It thus appeared, that the larvæ of whiting were distinct from corresponding stages of the cod (*G. callarias*), green cod (*G. virens*), pollack (*G. pollachius*) and haddock (*G. aeglefinus*) by having yellow pigment as well as black. There is thus no difficulty in recognising the whiting larvæ from those species, but on the other hand, as things now stand, we are not in a position to separate the larval stages of *G. merlangus*, *G. Esmarki* and *G. minutus* (nor perhaps those of *G. luscus* and *G. Poutassou*).

Postlarval whiting have been described and figured by Mc Intosh & Prince, by Mc Intosh and by Masterman, and are well-known so far as the older stages are concerned.

Description

5½ mm. The tail is quite symmetrical, and indications of interspinous rays are completely wanting. The pectorals are fan-shaped folds. On the neck there are some large, stellate chromatophores, as also on the lateral aspects of the abdomen. A distinct preanal row of stellate chromatophores extends from in front almost to the anus. The postanal pigment consists of a ventral row of numerous, closely placed chromatophores extending almost from the anus to near the end of the tail. A corresponding dorsal row is present, but does not extend so far back as the ventral row. Anteriorly it extends over the pectoral region to the neck. Pigment is lacking on the sides between the dorsal and ventral rows.

Yellow pigment was present in living specimens, both between the black chromatophores in the dorsal and ventral rows as on the embryonic fin itself.

The stage described was the smallest found by the "Thor" in the waters at Iceland; specimens hatched on board at Iceland corresponded well with the figures in Mc Intosh and Prince (1889, pl. XVII, fig. 12).

6½ mm. The tail is quite straight. Fairly distinct indications of interspinous rays are present below and above in the caudal fin, but no trace of rays; the occipital pigment is strongly developed, but the abdominal pigment on the other hand is not very apparent. The preanal row is double and very well-marked; it extends from the throat right to the anus. The ventral row consists of numerous (ca. 30) small, closely placed chromatophores, which are all situated close to the marginal embryonic fin, and extend almost from the anus to the hindmost portion of the interspinous region in the caudal fin. The dorsal row does not reach so far back, but anteriorly extends over the pectoral region right to the pigment on the neck. No black pigment occurs on the sides between the dorsal and ventral rows in the specimen described (pl. II, fig. 1), but in others of about the same size (see for example Fig. 11 in the text), dorsolateral and ventrolateral chromatophores have already developed about the centre of the postanal portion of the body, whilst nothing is found of the mediolateral pigment. Pl. II, Fig. 1

7 mm. The tail is quite straight. Extremely weak signs of rays can be detected below and above in the caudal fin, but on the other hand all signs of rays or interspinous rays are lacking in the remaining unpaired fins. The pigment is almost as in the specimen represented in Fig. 11, a number of dorsolateral and ventrolateral chromatophores being present about the centre of the postanal portion of the body. Pl. II, Fig. 2, 2a

For the rest, both the dorsal and ventral rows are well-developed. If we observe the fish from below, we see, that the chromatophores in the ventral row, whose number is ca. 20—30, are situated along its whole length close up to the marginal embryonic fin.

Fig. 11. *Gadus merlangus.* "Thor", Station 171, 2nd July, 1904, 63° 46′ N, 22° 56′ W (South Iceland), Depth: 150 meters, young-fish-trawl, 30 meters wire. Natural size: 6·6 mm. The indications of interspinous rays in the caudal fin are not given in the figure.

The posterior chromatophores are more distant from one another than the anterior. The preanal row is almost doubled along the whole of its course from the throat to the anus and consists of ca. 16 well-marked, stellate chromatophores in all.

Pl. II, Fig. 3 **8 mm.** Distinct indications of rays are present both below and above in the tail, which is quite straight. The interspinous regions are beginning to appear in the positions of both anal fins and of D^3 and D^2 as low, non-transparent parts of the marginal fin. The ventral fins cannot yet be observed. The pigment shows a difference from the previous stage, in that there is distinctly more dorsolateral and ventrolateral pigment than before. The mediolateral region however is still free of pigment. Whilst the dorsal row extends forwards right to the pigment on the neck, posteriorly it does not reach so far as the ventral row. The preanal pigment is very strongly developed and extends from the throat to the anus.

Pl. II, Fig. 4 **9 mm.** In spite of the slight difference in length, the volume of the little whiting has increased somewhat considerably since the preceding stage. The end of the notochord is somewhat bent upwards: the length of its free portion is almost equal to the distance of its tip from the posterior margin of the caudal fin. Indications of rays are present everywhere in the caudal fin, except in a portion on both sides of the end of the notochord. Rays are laid down in all the other unpaired fins, but they are still but short and indistinct, and can only just be detected in D^1. The embryonic fin is still broad. The ventrals can be made out as low, knob-like processes. The position of the anus is a little in front of the developing D^2.

As before, both the occipital and preanal pigments are well-developed. The postanal pigment is very apparent, and only a somewhat narrow part mediolaterally is now free of pigment; the dorsal row reaches further backwards than previously, yet not so far as the ventral row. The chromatophores of the latter have now removed somewhat from the marginal anal fin. Yellow pigment is present on the sides and on the dorsal and ventral aspects between the black chromatophores as well as on the neck, but not mediolaterally.

Pl. II, Fig. 5, 5a, 5b **11 mm.** The free end of the notochord is ca. $^1/_4$ of the distance from its tip to the posterior border of the caudal fin; it was even more reduced in other specimens of the same size. There is now only an extremely narrow portion in the caudal fin which is free of rays. Fairly distinct rays are present in all the other unpaired fins, most distinctly in D^2. On the proximal portion of A^2, as also in part on A^1, there are a few, black spots of pigment between the rays. The rays in the dorsal and anal fins do not reach out quite to the margin of the embryonic fin, which is still very broad. The ventrals are no longer knob-like, but yet extremely small, distinctly less than $^1/_4$ of the diameter of the eye. Neither the ventrals nor pectorals show any pigment; the latter are large, fan-shaped folds with embryonic rays as well as a few indistinct indications of true rays. The position of the anus is a fairly considerable distance in front of the developing D^2.

The pigment has not altered from the previous stage.

13 mm. The end of the notochord is almost wholly reduced, and rays are present everywhere in the caudal fin. The embryonic fin is now considerable lower opposite the interspaces between the developing fins than in the previous stage, and the most central rays reach out quite to the margin of the fin. The developing fins are lower and less sharply bounded-off than in the young haddock of the same size. In A^1 some twenty odd indications of rays could be counted, in A^2 scarcely twenty. The ventrals are very small, not half so long as the diameter of the eye and, like the pectorals, are lacking in pigment. The anus is placed a good distance in front of the developing D^2. D^1 is extremely low, much lower than in the haddock (*G. aeglefinus*). A^1 is considerably longer than A^2. There is a little pigment on the anal fins near the base, especially on A^2. Pl. II, Fig. 6

The pigment is a little more diffuse and a little weaker than previously; otherwise there is no change. The greater part of the sides is now pigmented; yet the mediolateral region is still almost free of pigment (and also lacks yellow pigment).

16 mm. The end of the notochord is quite reduced. The unpaired fins are now only connected by a low membrane. Both the dorsal and anal fins are still but low; this holds especially for D^1, in which I could count ca. 9 distinct rays, A^1 is lower and much longer at the base than A^2. In A^1 there were ca. 28, in A^2 20 developing rays, some of which however were but indistinct. In D^2 there were ca. 13, in D^3 ca. 15 developing rays. There is a little pigment between the rays in all the unpaired fins, most in D^2. Further a black chromatophore is present on each interspinous ray in the dorsal and anal fins. The ventrals are scarcely half so long as the diameter of the eye, and they reach to about $^1/_3$ of the distance from their base to the anus. Pigment is lacking in both ventral and pectoral fins. Pl. II, Fig. 7

As can be seen from the figure, the pigment is but weak, but yet is over the greater part of the sides. In other specimens it was more developed. The preanal row is still very distinct.

23 mm. The unpaired fins are practically quite distinct. The caudal is almost square posteriorly. D^1 is still a little lower than the other dorsal fins. A^1 is much lower and longer than A^2. In A^1 there were at least 30, in A^2 at least 22 rays, but the most anterior and most posterior are still far from distinct. There is a little pigment on all the unpaired fins. The ventrals have about the same length as the diameter of the eye and reach scarcely halfway to the anus, measured from their base. Pigment is lacking in both ventral and pectoral fins. The anus lies almost under the middle of D^1. Pl. II, Fig. 8

The pigment (also the yellow) is evenly, but not very densely, distributed over the sides. The preanal row is still distinct.

32$^1/_2$ mm. The caudal fin is almost square. The dorsal and anal fins have attained essentially their permanent form. D^1 also is now higher than the other dorsal fins. A^1, which has at least 30 rays, is much longer and lower than A^2, the number of rays in which is 23. There is some pigment on all the unpaired fins. The ventrals are ca. $3^1/_2$—$3^3/_4$ mm. long or about $1^1/_2$ times as long as the diameter of the eye. Posteriorly, they extend a little beyond the beginning of A^1. They are lacking in pigment. In the pectorals 19 very distinct rays were counted; some small chromatophores are present along their upper and posterior borders. The anus lies under the anterior $^1/_3$ of D^1. Pl. II, Fig. 9

The pigment on the sides is much denser than before, though on the whole it is not more intense. It is weakest mediolaterally, strongest dorsolaterally, where there are some groups of pigment (see Figure, Pl. II) which appear as a row of darker spots on the sides under the dorsal edge of the body. When these spots are specially strong in the young whiting, which is not seldom the case, the pigmentation may remind one somewhat at first glance of the chequered pigmentation of the young cod.

To figure and describe still older young of the whiting seems to me superfluous; they will easily be recognised from most other species by the very long A^1 and the position of the anus under the

anterior 1/3 of D^1. A similar relation is found only in *G. luscus*, which differs from the whiting by its much greater height of the body, higher D^1 and the presence of a long barbule, as in *G. Poutassou*, which is directly distinguished from the whiting by the great distance between D^2 and D^3.

The young of the whiting have a longer pelagic existence than most of the other gadoid species.

Material

The material from Iceland contains many hundreds of pelagic young of whiting in all stages and shows the developmental series very perfectly.

Verification of the determinations

This will be given after the Norway pout (*G. Esmarki*) has been described.

Occurrence within the region under observation

Pelagic young of the whiting were found in quantities at South and West Iceland, at the Færoes, in the North Sea, Skager Rak and Kattegat. The pelagic young of the whiting occur in the Danish waters within the Skaw, especially later on in the summer time.

7. *Gadus Esmarki* Nilsson, Norway pout

Principal literature and figures:

Larval stages: Holt (1891, p. 54, pl. VI, fig. 46—47).? — Postlarval and early young stages: undescribed.

Nothing certain has hitherto been known regarding the early developmental history of this species. The tiny larval stages described by Holt (l. c.), which were hatched from eggs taken on April 18th 1891 in Cleggan Bay (Ireland) in the surface net, belong possibly to *G. Esmarki*, but no certain proof of this is forthcoming. They resemble the larva, which is figured by Holt on the same plate (pl. VI, fig. 50) as belonging to the whiting (*G. merlangus*), to such an extent that any difference of importance cannot be observed.

I have not myself had the opportunity on board the "Thor" of settling the question by hatching the artificially fertilised eggs of the Norway pout.

It appears from our observations with the "Thor", that *G. Esmarki* is an extremely common fish at least in certain places. This holds for the south and west coasts of Iceland (cf. for example page 2, where the contents of a haul with the young-fish-trawl are stated), and it is one of the commonest fish in the Skager Rak according to Dr. A. C. Johansen, who has investigated this region with the "Thor". We may expect, therefore, that its pelagic young occur in quantities in collections. This has indeed proved to be the case.

Description

6 mm. The youngest stages, I have yet examined, measured ca. 6 mm. (see text-figure 12) and came from Iceland. The notochord is quite straight. Indications of the interspinous regions are present below and above in the caudal fin, but not in the other fins. The pectorals are fan-shaped folds of skin, and the ventrals are quite lacking.

The eyes are relatively small. The pigment is very characteristic. The occipital pigment consists of 4 round, stellate chromatophores situated some distance from one another. The preanal pigment is well-developed; it consist of 8 large chromatophores, but it does not reach so far back as to the anus.

The abdominal pigment is tolerably weak. The sides are free of pigment. The ventral pigment consists of a row of ca. 20 large, stellate chromatophores. Towards the end of the tail the row decreases gradually in intensity, the posterior chromatophores being separated by greater interspaces than those placed further forward. The 15 posterior ventral chromatophores are marginal, whereas those in front have begun to bend a little from the margin, so that the row thus shows an incipient forking (cf. the following stage and Pl. III, Fig. 1 a). The dorsal pigment is present on the stretch right from the pectoral region to near the end of the tail, but consists in all of only ca. 15 chromatophores, which are most often smaller than the ventral and are separated by much greater interspaces. Behind the anterodorsal chromatophores, which are the smallest, there is a large part free of pigment (in contrast to the whiting) from about the region of the anus, and then 6 strong posterodorsal spots follow. The most posterior of these is placed further back than the most posterior ventral chromatophore, but in other specimens the condition may be reversed. Yellow pigment is present in living specimens between the black on the head as well as dorsally and ventrally.

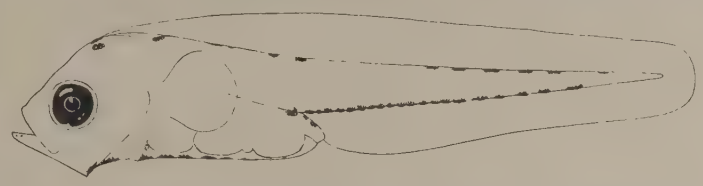

Fig. 12. *Gadus Esmarki* Nilsson. Young postlarval stage. "Thor" Station 163, June 27th 1904, 65° 10·5′ N., 24° 05′ W. Depth: 150 meters; young-fish-trawl, 85 meters wire. Natural size 6 mm. Indications of interspinous rays in the tail are not given in the figure.

6¾ mm. The notochord is quite straight. There are fairly distinct indications of rays both below and above in the region of the caudal fin, and slight indications of the interspinous regions are to be seen in A^2 and D^3. Ventral fins are wanting. Pl. III, Fig. 1 and 1 a

The occipital pigment consists of a few (ca. 5) round, well-separated chromatophores. The abdominal pigment is weak and not on the surface for the most part. The chromatophores of the preanal pigment are placed tolerably distant from one another, but are strongly developed. The row does not reach so far back as to the anus. The lateral aspects are pigmentless, the pigment being restricted to the ventral and dorsal rows. The latter contains fewer and more widely separated chromatophores than the former, but usually extends further backwards. On the pectoral region anteriorly there are ca. 5 well-separated chromatophores; there is then a large pigmentless interspace dorsally (over the anal region) and this is followed finally by 5 posterodorsal chromatophores, which are larger than the front dorsal ones. The ventral pigment shows a characteristic advance on the previous stage, which becomes specially apparent when the fish is observed from the ventral aspect. The ventral pigment then appears as a bifurcated row of large, stellate chromatophores. This bifurcation has arisen from the anteroventral chromatophores becoming shifted a little from the ventral margin, whilst the posteroventral remain in their original position. (See Plate III, Fig. 1 a, and, for a comparison with the whiting, Plate II, Fig. 2 a). The anteroventral pigment consists here of 4 pairs, the posteroventral of 5 marginal chromatophores, the most posterior of which is separated from the one in front by a considerably greater interspace than exists between any of the others.

Even though the number of the postanal chromatophores may vary somewhat, the Norway pout in these young stages is still constantly characterised, as contrasted with the whiting, by the fewer and larger chromatophores. The anterodorsal portion of the pigment is, especially, less developed than in the whiting.

8½ mm. The end of the notochord is almost quite straight. Distinct indications of rays are present both below and above in the caudal fin. In D^2, D^3, A^1 and A^2 there are low, but yet distinct indications of the interspinous regions. The ventral fins cannot be detected with certainty. Pl. III, Fig. 2

The occipital pigment consists here of a pair of large, round, well-separated chromatophores. The preanal pigment is as in the specimen last described. The bifurcation of the ventral pigment is still very characteristic; there are 7 posteroventral and 6 pairs of anteroventral chromatophores. Behind the anus dorsally there is a small number of large, very widely separated chromatophores; in front of the anus there is one pair separated by a still larger interspace. Further, the dorsal pigment reaches further back here than the ventral; but this relation is by no means constant.

Pl. III, Fig. 3 **10¼ mm.** The end of the notochord is somewhat bent upwards. The length of the free portion is already less than the distance from its tip to the posterior margin of the caudal fin. With exception of a portion on both sides of the end of the notochord, rays are now everywhere present in the caudal fin. All the unpaired fins except D^1 show the beginnings of rays, which are however still faint. They are most distinct in the two anal fins and in D^3. The following number of rays could be detected: D^2 ca. 10, D^3 ca. 14, A^1 ca. 12, A^2 ca. 17. The developing rays are still far from reaching out to the margin of the broad embryonic fin. The pectorals are fan-shaped, but not any larger; they have still only embryonic rays. The ventrals can be detected as tiny knobs under or a little behind the pectorals.

The pigment shows a change, in that the ventral row is now no longer bifurcated, the posteroventral chromatophores having also moved from the margin. Viewed from the ventral aspect the ventral pigment now shows as a double row of large, stellate chromatophores on each side of the marginal fin. In the specimen examined there was relatively a good deal of dorsal pigment, which was however much weaker (fewer and smaller chromatophores) than the ventral pigment; this is especially the case as a rule as regards its front portion. A single dorsolateral or ventrolateral chromatophore may sometimes be present far back on the sides, but otherwise these are free of pigment (cf. the whiting). The preanal pigment is fairly well-developed, and the occipital pigment consists as before of a small number of large round chromatophores. In living specimens there is some yellow pigment between the black chromatophores especially on the head and postanally on the dorsal and ventral aspects.

Pl. III, Fig. 4, 4a og 4b **13 mm.** The end of the notochord is strongly bent upwards. The length of its free portion is only ca. 1/6 of the distance from its tip to the posterior border of the caudal fin. There is now only a very narrow part remaining free of rays in the caudal fin. Developing rays are present in all the unpaired fins. The following number could be counted: D^1 ca. 4, D^2 ca. 15, D^3 ca. 19, A^1 ca. 18, A^2 ca. 20. The central rays in the various fins reach out to the margin of the fin. The developing rays are throughout but weak, and it thus appears for this species, that even though the rays are formed early, they remain still some time at a low stage of development. D^1 is extremely low. The embryonic fin, which binds the developing fins, is still broad; the pectorals, which are fan-shaped, are short; in their upper part there are now indications of ca. 6—7 rays. The ventrals, which are placed almost under the pectorals, are still wart-like.

The occipital pigment consists of a small number of large, round, well-separated spots. The abdominal row is very faint and for the most part not superficial. The preanal row is fairly well-developed and reaches posteriorly almost to the anus. The ventral pigment consists of ca. 10 large stellate chromatophores on each side of the median fin. On the other hand, the dorsal pigment is much weaker, especially anteriorly. As can be seen from Fig. 4 of Plate III, the hindmost dorsal (sometimes also the ventral) chromatophores have spread a good deal downwards (or upwards) on the sides. For the rest, these are quite without pigment.

The fins lack all trace of pigment.

Pl. III, Fig. 5 **16 mm.** The end of the notochord is now almost entirely reduced. The posterior border of the caudal fin is a little concave. The embryonic fin between the developing fins is but small. D^1 is still extremely

low and separated from D^2 by a considerable interspace; ca. 7 very short developing rays could be counted. In A^1 there were ca. 20, in A^2 ca. 22 developing rays. The pectorals are short, but broad and fan-shaped; they have now ca. 11 developing rays in their upper part, but the rays are only weak, not much more distinct than in the previous stage of 18 mm.[1] The ventrals are very short, less than 1/4 of the diameter of the eye. Pigment is quite wanting in all the fins.

The anus lies immediately in front of the developing D^2. The eyes are relatively small, their diameter being almost of the same size as the distance from their anterior margin to the end of the snout. The form of the body is very slender and tails off quite evenly posteriorly, the height in front of the anus being not much larger than that immediately behind this. The body also decreases very evenly in thickness posteriorly. The contour of the back is very straight.

The pigment does not show any essential change from the preceding stage, except that the large ventral chromatophores have moved a little more from the margin. A single isolated lateral chromatophore may sometimes be present. The dorsal pigment is very little constant and most often faint. The preanal row is fairly well-developed and reaches almost to the anus. The few, large, well-separated occipital chromatophores are still characteristic.

19 3/4 mm. The caudal fin is concave posteriorly. The embryonic fin between the developing fins has now practically disappeared. The first dorsal fin is very low and separated from D^2 by a large interspace; ca. 10 rays can be counted in it. In A^1 there were ca. 24, in A^2 ca. 27 developing rays. The ventral fins are very short, not 1/4 of the diameter of the eye. The anus lies immediately in front of D^2. The eyes are relatively small, their diameter being of the same size as or but little larger than the distance from their anterior margin to the end of the snout. The body decreases from before backwards with quite extraordinary uniformity, the height in front of the anus not being (as in *Gadus minutus*) much greater than the height immediately behind the anus. The contour of the back from the postorbital region is almost horizontal (in contrast to *G. minutus*)[2]. Pl. III, Fig. 6

The pigment is almost the same as in the previous stage, except that the dorsal spots are here a little more numerous. Some scattered lateral chromatophores are present opposite the boundary between the caudal fin and the posterior dorsal and anal fins. The preanal pigment is now but faint. The occipital chromatophores are still few and widely separated.

23 mm. The caudal fin is deeply concave. The unpaired fins, of which D^1 is still very low, are quite separated. In D^1 ca. 11 rays were counted, in A^1 ca. 28 and in A^2 ca. 27. The ventrals are still very short, not half so long as the diameter of the eye. The position of the anus is somewhat in front of D^2; the size of the eye is relatively small (as in the previous stage, the diameter is almost equal to the distance from the margin of the eye to the end of the snout). The underjaw reaches a good distance forwards in front of the snout, which is not rounded as in *Gadus minutus* but ends bluntly. The form of the body is very slender and the height in front of the anus is relatively small. This appears distinctly, when we compare the specimen figured (Pl. III, Fig. 7) with *G. minutus* (Pl. III, Fig. 17) of the same size. The difference between the two species in this regard is sufficiently apparent. Still more striking perhaps is the difference in the thickness of the body in front of the anus in the two species. If we observe the specimens from above, we see, that the body Pl. III, Fig. 7

[1] To illustrate the development of the rays in the pectorals, the following may be stated: length, 10 mm.: no rays. — length, 13 mm : 6—7 rays. — length, 16 mm.: ca. 11 rays, the lowermost of which are but faint. — length, 20 mm.: ca. 16 rays. — length 24 3/4 mm: 18 rays. — length, 27: 19 rays, the lowermost of which are extremely short and faint.

[2] In preserved specimens of this and other *Gadus*-species, the body is often bent in an unnatural fashion, so that it becomes convex dorsally and concave ventrally. This applies partly also to the specimen represented in Fig. 6, Pl. III. A specimen quite normal in appearance (length, 28 mm.) is however shown in text-figure 15. page 49, for comparison with *G. minutus*.

in front of the anus in *Gadus Esmarki* is compressed and narrow and decreases posteriorly quite evenly in thickness. In a *Gadus minutus* of the same size the preanal portion of the body, seen from above, appears extremely broad and big in comparison with the slender postanal portion, so that the fish plainly seems enlarged to a club-shape anteriorly. By a comparison of figures 7 and 17 of Pl. III it may further be remarked, that there is a great difference in the size of the eyes, in the form of the snout and in the size and form of D^1. The pigment on the other hand is very similar in the two species (in the *Gadus minutus* figured the pigment is much fainter, which is however mostly due to the fact, that the specimen in question has lain some years in spirit).

The pigment has practically not altered since the preceding stage; there is however a little more dorsal pigment. The sides are still practically free of pigment. The preanal pigment is now but faint, consisting of a single row of small points. Pigment is quite lacking in all the fins (cf. the whiting, *Gadus merlangus*, which has pigmented fins even at a much smaller size).

28½ mm. A specimen of 28½ mm. in length is represented in text-figure 15, page 49, along with others of the same size of *G. minutus* and *G. luscus*, in order to show the differences in form, pigmentation etc. between the three species. From these one can see the relatively small eyes; the slender form and small body height in front of the anus in *G. Esmarki*, as well as that the tail is deeply concave. Further, the prominent underjaw, the blunt snout and the considerable interspace between D^1 and D^2 are characteristic. In A^1 there were ca. 28 rays, in A^2 ca. 26 and in D^1, which is now a little higher than D^2, ca. 12. The ventrals are short, scarcely so long as the diameter of the eye, and they do not reach nearly half-way to the anus. This lies under the posterior portion of D^1.

Concerning the pigment it has to be remarked, that there is considerably more dorsal pigment than previously. On the other hand the sides are still pigmentless. Some pigment spots are present on the proximal portion of the caudal fin. Further, a single black chromatophore is present on most of the rays at their proximal ends in D^2 and A^2, especially the latter.

Pl. III, Fig. 8 **30 mm.** Like the foregoing, the present specimen was taken on the south coast of Iceland near the bottom. It does not differ in any essential degree from the last described. The fairly large distance between D^1 and D^2 is worthy of remark. The ventrals are now quite as large as the diameter of the eye and reach almost halfway to the anus. The pigment is almost as in the previous stage. The greater part of the sides is still perfectly free of pigment.

Pl. III, Fig. 9 **54 mm.** I have figured the young bottom-stage of this size in order to show, how the pigment and especially the dorsal pigment gradually spreads over the sides. Almost the whole of the ventrolateral region, however, is still pigmentless or less densely and strongly pigmented. Most of the lateral chromatophores added since the preceding stage are quite fine points, which are however extremely dense, especially in the dorsolateral region. There are often some slightly darker groups of pigment on the dorsal margin. The unpaired fins (at least the anal fins) now show faint pigment.

There were 14 rays in D^1, 25 in D^2, 26 in D^3, 30 in A^1 and 27 in A^2.

The ventrals are considerably larger than the diameter of the eye and when undamaged reach almost to the anus. Specimens of this size are very easily distinguished from *G. minutus* by the characters already mentioned above (form of the snout, small height of the body, distance between D^1 and D^2, the concave caudal fin etc.). Further, specimens of *G. minutus* of this size are already provided with a long barbule (cf. Collet, 1875, p. 109).

Material

The material from Iceland contains many thousands of the pelagic young of the Norway pout in all stages and shows the whole developmental history very completely.

Verification of the determinations

This was carried out on the Icelandic material by means of the series-method. Three species of pelagic gadoid young of the II main group occurred in the coastal waters round Iceland and all three in quantities (thousands of specimens). One of these three species is already known to be the haddock (*G. aeglefinus*), as has been mentioned on pages 35, 36. Two species thus remained, which could easily be distinguished: by the sides in the one being pale (pigmentless) but in the other strewn over with pigment. In the first, there were but few, large stellate chromatophores, whilst the second had more numerous and smaller. Even by means of these differences in the pigmentation, developmental series were established from the delicate postlarval stages up to those having a length of ca. 5 cm.

In a specimen of 30 mm. belonging to the series with sides free of pigment and which had apparently reached its full number of rays, the following were counted: $D^1 = 15$, $D^2 = 24$, $D^3 = 25$, $A^1 = 27$, $A^2 = 27$. These numbers show, that this specimen and thus the whole series without pigment on the sides belong to *G. Esmarki*, as in no other species, with exception of *G. Poutassou*, is there such a high number of rays in A^2. *G. Poutassou* is easily excluded, however, as it has only 12—14 rays in D^2 (see the summary given on page 53). For the sake of complete certainty I counted the fin-rays in A^2 and D^2 in 4 other specimens (length about 30 mm.) of the series with pigmentless sides and thus obtained the following numbers[1]:

rays in A^2	27	27	26	27	27
rays in D^2	24—25	25	24	25	26

These show with certainty, that the young fishes and thus the whole Icelandic series of *Gadus*-young with unpigmented sides belong to *Gadus Esmarki*, which we also knew from our trawlings to be exceedingly common at Iceland.

There still remained to identify the last series of pelagic *Gadus*-young from the coastal waters round Iceland, the species namely in which the greater part of the sides was overstrewn with pigment. As this species, like *G. Esmarki*, occurs in quantities in the collections, *G. minutus* and *G. luscus* which are not found at Iceland[2] could at once be excluded. There remained then the whiting (*G. merlangus*) and the poutassou (*G. Poutassou*) as the only possibilities.

In two specimens (24 and 27 mm. long) the following number of rays was found: A^1 31, A^2 22, D^2 22 and A^1 32, A^2 21, D^2 23.

These number show, that the series in question belonged to the whiting (*G. merlangus*), and the position of the anus (under the anterior $^1/_3$ of D^1) as well as the form of the dorsal and anal fins agreed with this conclusion. The poutassou (*G. Poutassou*) could also be at once excluded, as D^2 and D^3 were touching one another, whereas in this species they are separated by a large interspace.[2]

Occurrence within the region under observation

The pelagic young of *G. Esmarki* were found in quantities by the "Thor" at South and West Iceland, as also as at the Færoes, in the North Sea and Skager Rak. In the Danish waters within the Skaw it is met with sometimes, though not in large quantities and chiefly in the northern Kattegat.

[1] In 7 adult *G. Esmarki* from Iceland I found the following number of rays:

A^1: 29, 28, 30, 29, 29, 27, 27
A^2: 26, 26, 30, 28, 27, 25, 27

[2] Although it is superfluous, as a matter of fact, to consider the possibility, that the young of the two more southerly species *G. minutus* and *G. luscus* might occur in quantities at Iceland, I may yet mention, that *G. minutus* is at once excluded by the number of rays in the anal fins and the position of the anus, *G. luscus* by the small height of the body and the separation of A^1 and A^2.

8. *Gadus minutus* O. F. Müller, poor cod

Gadus minutus: B. Fries (1837–38), Krøyer (1843), Lütken (1881), Day (1882 & 1888), Lilljeborg (1891).

Non *Morua capelanus* Risso — nec *Gadus minutus* Moreau

Is Gadus minutus an independent species?

A certain amount of obscurity reigns in the literature with regard to *Gadus minutus*. Some authors consider it to be an independent species, others deny that it is specifically distinct from *Gadus luscus* Linné. To the latter belong, for example, Steindachner (1868), Winther (1879–80, p. 29–30), Möbius and Heincke (1884, p. 225) and Smitt (1892, I, 495), to the former, in addition to the authors cited above, Mc Intosh (1888, p. 348), Heincke & Ehrenbaum (1900, p. 254).

The most recent author, who has so far as known to me dealt with this question in a detailed manner, is Smitt, who in the second edition of "Skandinaviens Fiskar" (1892, I, p. 498–99) gives a number of measurements of older *G. minutus* and *G. luscus*, and as result expresses himself in the following manner: "De båda arterna, om man så vil benämna dem, stå således i et mycket intimt utvecklingsförhållande till hvarandre; och luckorna mellem de angifna maximi- och minimitalen skulle helt säkert i de flesta, om ej i alla, förhållandena hafva blifvit fylda, om vi haft tillgång till yngre exemplar af *Gadus luscus*. Mellan Riksmuseets största exemplar af *Gadus minutus* (210 mm.s kroppslängd) och minsta exemplar af *Gadus luscus* (297 mm.s kroppslängd) är nemligen lucken tilräckligt stor för at medgifva betydliga åldersförandringer", and later ". . . skäggtorsken (*G. luscus*) har tidligen sitt egentliga hemvist kring Storbritannien, norrut och söderut blifver han mer och mer sällsynt, ju längre derifrån; men vid Skandinavien og ännu talrikare i Medelhafvet uppträda hans ungdomsskeden[1] med en viss sjelfständighet i färg och form. At dessa skeden äfven vid England hålla sig skilda från de äldra, på olika djup och oftast olika botten, öfverensstämmer med vår erfarenhet om andra torskarters olika åldrar . . ."[2]

In Smitt's opinion, therefore, *G. minutus* is only the young stage of *G. luscus*, and he thus differs from the view put forward by Fries in the first edition of "Skandinaviens Fiskar" (1837–38), which has later been confirmed by other Scandinavian and British authors (e. g. Lütken 1882, Day 1888, Mc Intosh 1888 and Lilljeborg 1891), that *G. minutus* and *G. luscus* are two well-separated species. The evidence brought forward by Smitt was also extremely faulty, or more correctly, there is practically no evidence, as the measurements given of specimens of *G. minutus* and *G. luscus* just show a considerable difference between the two species, and Smitt has thus recourse to saying, that if it had been possible to examine younger specimens of *G. luscus* (the smallest was 297 mm., the largest of *G. minutus* 210 mm.), the gaps between them would certainly have been filled up[3]. Smitt thus recognises, therefore, that the question has to be solved by an investigation of the young stages.

As the question is naturally of importance for the present work, and also, as there still seems some uncertainty amongst ichthyologists regarding this matter, I have utilized my material, which is rich and contains, in addition to the postlarval stages, the whole developmental series from the youngest bottom-stages to the adult fish, in order to test the matter thoroughly. An examination of this material, which comes from the English Channel, the west coast of Ireland, North Sea, Skager Rak and Kattegat,

[1] These young stages according to Smitt are = *G. minutus*.

[2] Translation: "The two species, if we call them so, thus stand in a very close developmental relationship to one another; and the gaps between the maximæ and minimæ would quite certainly have been filled up in most, if not all, of the proportions, if we had had younger specimens of *Gadus luscus*. Between the largest specimen of *Gadus minutus* (210 mm.) and the smallest of *Gadus luscus* (297 mm.) the gap is sufficiently large to permit of considerable changes with age", . . . "the pout (*G. luscus*) has evidently its true home round Great Britain, becoming more and more rare the further we go from there to the north or south; but its young stages appear with a certain independence in colour and form at Scandinavia and still more frequently in the Mediterranean. That these stages even at England keep separate from the older, on different grounds and different depths, agrees with our experience concerning the different stages of other gadoids . . ."

[3] Smitt says indeed: "och luckorna . . . skulle helt säkert i de fleste, om ej i alla, förhallandena hafve blifvit fyllda . . ." The meaning here is thus not clear, as either *G. minutus* and *luscus* are two species or they are not two species.

has shown, that *G. minutus* and *luscus* from these waters are two species very distinctly separated throughout all developmental stages. I shall give here some measurements of the bottom-stages of various sizes from 50 mm. onwards.[1]

	Gadus luscus Linné[2]									*Gadus minutus* O. F. Müller[3]								
Total length (Millim.)	50—100 (11 spec.)			100—200 (2 spec.)			More than 200 (7 spec.)			50—100 (10 spec.)			100—200 (8 spec.)			More than 200 (4 spec.)		
	min.	med.	max.	min.	med.	max.	min.	med.	max.	min.	med.	max.	min.	med.	max.	min.	med.	max.
Greatest height in % of the total length	22	**24**	25	25	**26**	27	27	**29**	34	19	**19**	19	19	**20**	21	21	**22**	22
Greatest height in % of preanal length	76	**79**	84	90	**92**	93	97	**102**	111	55	**58**	62	57	**60**	63	62	**64**	68

Further, I may give the following separate measurements of 3 × 2 specimens of equal size belonging to the two species. These measurements can be regarded as typical for the stages in question.

	G. luscus (Plymouth)	*G. minutus* (Kattegat)	*G. luscus* (Ireland)	*G. minutus* (North Sea)	*G. luscus* (North Sea)	*G. minutus* (Skager Rak)
Total length (mm.)	74	74	93	91	222	225
Preanal length (mm.)	23	24	27	32	62	73,5
Greatest height (mm.)	18	14	22	17	60	50
Length of A^1 (mm.)	24	19	31	26	77	65
Length of A^2 (mm.)	12	13	14,5	17	35	37
Greatest height in % of the Total length	24 %	19 %	24 %	19 %	27 %	22 %
A^1 in % of the preanal length ..	104 %	79 %	115 %	81 %	124 %	88 %
A^2 in % of A^1	50 %	68 %	47 %	65 %	45 %	57 %

The measurements given, which obviously require no further explanation, show, that there is a great difference between *Gadus luscus* and *G. minutus* even in the smallest bottom-stages[4] examined. There are several characters, by means of which the two species can always be readily distinguished from one another. As one of the most obvious may be mentioned the length of the base of the first anal fin in relation to the distance from the anus to the tip of the snout ("preanal length"): in *G. minutus* the base of A^1 is distinctly shorter than the preanal length at all stages. In the youngest *G. luscus* (about 50 mm.) the base of A^1 is almost equal to, in the older considerably longer than the preanal length. By examining the relation between the length of A^1 and the preanal length I have always been able to determine at once, if the specimens over 50 mm. belonged to the one or the other species.

There is further the height of the body, which, as can be seen from the measurements above, is distinctly larger in *G. luscus* than in *G. minutus* at all stages, also, the relation between the lengths of the bases of A^1 and A^2.

[1] The largest and the highest numbers found are given for the specimens examined in addition to the averages, so that the reader can form an idea of the extent of the variation and thus control the value of the data.

It has to be remarked, that fractions greater than $^1/_2$ are taken as wholes. The "preanal length" is the distance from the centre of the anus to a line drawn perpendicularly to the longitudinal axis of the fish through the tip of the snout.

[2] The specimens examined came from the English Channel, the west coast of Ireland, North Sea, Skager Rak and Kattegat. The lengths in millimeters were as follows: 50, $57^1/_2$, 62, 62, $67^1/_2$, 68, 74, 74, $74^1/_3$, 93, 97, 149, 190, 222, 265, 275, 284, 301, 340, 355.

[3] The specimens examined came from the English Channel, the west coast of Ireland, North Sea, south Norwegian fjords, Skager Rak and Kattegat. The lengths in millimeters were as follows: 50, 64, 74, 75, 76, 82, 83, 83, 85, 91, 105, 139, 154, 157, 158, 161, 167, 167, 210, 212, 212, 225.

[4] As will be seen later, the differences in the postlarval stages are at least quite as great.

Concerning other obvious distinguishing characters, it may for example, be mentioned, that A^1 and A^2 are separated in *G. minutus*, but in *G. luscus* practically always connected[1]. In *G. luscus* the highest point of D^3 and A^2 lies very far back, so that the anterior parts of these two fins are almost parallel, which is not the case in *G. minutus*. In *G. luscus* the posterior border of the caudal fin is almost straight, in *G. minutus* more concave. The position of the anus in relation to D^1 is very different in the two species; in *G. luscus* it is lying under the anterior, in *G. minutus* under the posterior third of D^1. Concerning the remaining differences, reference may be made to LILLJEBORG's description of the two species. (See also DAY [1888, p. 151] and MC INTOSH [1888, p. 348]).

In some older specimens I found the following number of rays in A^1 and A^2.

Gadus minutus			*Gadus luscus*		
Locality	Number of rays in A^1	Number of rays in A^2	Locality	Number of rays in A^1	Number of rays in A^2
Kattegat	27	20	Kattegat	32	22
»	26	21	North Sea	30	21
Skager Rak	29	21	»	30	21
»	27	21	»	31	20
»	28	21	English Channel	34	21
»	28	21	»	33	19
»	26	21	»	31	20
»	28	20	»	30	19
»	26	21	»	31	20
»	29	21	Ireland	30	19
»	28	21	»	31	19

What has hitherto been said holds for the adult fish or younger stages down to a length of 50 mm. I have not included still younger developmental stages in the tables of measurements, as measurements taken in the usual manner (by means of compasses) can easily be too inexact to give any reliable result, when such small fish are being examined. In order to show the differences between the two species in the youngest bottom-stages, I give below a figure of a *Gadus luscus* (Fig. 13) and one of *Gadus minutus* (Fig. 14) of the same length ($27^1/_2-28$ mm.). For the sake of comparison, a *Gadus Esmarki* of about the same length is shown (Fig. 15). The three figures have been drawn with the help of the *camera lucida* immediately after one another and with the same adjustment. From an observation of these figures we can easily see, that, as regards the form of the body, the position and form of the fins, and the pigmentation, *Gadus minutus* differs in high degree from *Gadus luscus*, and approaches more to *Gadus Esmarki* in these features. For the rest, reference may be made to the following description of the developmental history of *G. minutus* and *G. luscus* with respect to these and still younger stages.

It has now been shown, that *G. luscus* and *minutus* from the west and north European waters are well-separated in all developmental stages down to the youngest bottom stages of less than 3 centimeters in length. It will be seen later, that they are also extremely well-separated in the pelagic, post-larval stages.

Before leaving this question, I distinctly wish to make it clear, that what has been said here holds for the *G. minutus*, which occurs around Great Britain, in the North Sea, Skager Rak and Kattegat, but not on the other hand for the Mediterranean gadoid species, which in literature goes under the name of *Gadus minutus* or "capelan" (*Morua capelanus* Risso) with several more recent authors (e. g. RAFFAELE, MOREAU, MARION, HOLT). LILLJEBORG (1891) has maintained, that the Mediterranean "capelan"

[1] Only in one of the specimens of *G. luscus* examined was the membrane between them almost divided. In *G. minutus* there is a distinct interspace between the two fins.

is not identical with the British and northern *Gadus minutus*. Seeing that MOREAU in his treatise on the Fishes of France (1881, III, p. 232) says regarding the distribution of his "*G. minutus*" ("le capelan"), that it is "très commun" in the Mediterranean from Nice to Port Vendres, whilst he further says: "j'avoue n'avoir jamais vu le Capelan sur nos côtes de l'Ouest", it seems to me possible, that "le capelan" is perhaps not identical with the Scandinavian and British ichthyologists' *G. minutus*, since as a matter of fact this is common in the English Channel. I have not had the opportunity myself of examining sufficient material from the Mediterranean to be able to settle the question regarding the systematic position of the Mediterranean specimens.

Fig. 13. *Gadus luscus* Linné. **Length 28 mm.** Cawsand Bay (Plymouth), 23. August 1897.
[Note: height of the body, position of the anus in relation to D^1, the strong pigmentation of the sides and fins, the junction of the two anal fins and the square caudal fin.]

Before going further, I should like to bring together the results of the above discussion, as follows:

(1) In the waters round Great Britain, in the North Sea, Skager Rak and Kattegat, there occur two gadoid species well-separated throughout their whole lite, namely, *Gadus luscus* Linné and *Gadus minutus* O. F. Müller.

Fig. 14. *Gadus minutus* O. F. Müller. **Length 27½ mm.** Plymouth Sound 22—25. May 1899.
[Note: height and form of the body, position of the anus in relation to D^1, the unpigmented sides, the separation of the two anal fins and the rounded snout.]

(2) That the Mediterranean "capelan" is identical with the British and northern *Gadus minutus*, is denied by LILLJEBORG, who has compared specimens from Nice with northern specimens, and must in any case be proved before we can draw conclusions as to the appearance of the young of the British and northern *Gadus minutus* from the appearance of the young of "le capelan".

Fig 15. *Gadus Esmarki* Nilsson **Length 28½ mm.** "Thor" Stat. 168 (64°18′ N, 22°08′ W. Depth 15 meters), Iceland 1. July 1904, at the bottom.
[Note: height and form of the body, the separation of D^1 from D^2, the form of the snout, size of the eye and the form of the caudal fin.]

I shall now pass to the description of the developmental history of *Gadus minutus*, as it is known to me through material from British, Norwegian and Danish waters, mentioning first of all the principal literature on the subject.

Principal literature and figures:

Larval stages: M'INTOSH (1893, p. 239, pl. VIII, fig. 4—8); non RAFFAELE (1888, pl. 1, fig. 25, pl. 2, fig. 20—21; nec MARION 1890, p. 118, pl. 2, fig. 14—15); nec HOLT (1899, p. 90); HOLT (1891, p. 52, pl. VI, fig. 51—52)? — Postlarval and earliest young stages: undescribed.

The only certain information we have concerning the early developmental history of this species comes from MC INTOSH (l. c.), who has succeeded in hatching out the artificially fertilised eggs of *Gadus minutus* from the North Sea, off Aberdeen, early in June. The larvæ just hatched are 2·3—2·4 mm. long and resemble those of the whiting, in having yellow pigment as well as the black. (See MC INTOSH l. c. pl. VIII, fig. 4, 6, 7). In the oldest of the stages figured by MC INTOSH (fig. 8), in which the yolk-sac is absorbed, a very distinct dorsal and also a ventral row of large, stellate chromatophores are to be seen.

The latter seems to extend further back than the former, as there is a single subnotochordal chromatophore near the end of the tail. To judge from Mc Intosh's figure, the pigment seems to resemble that of the whiting somewhat, but the whiting has more and smaller chromatophores than the *Gadus minutus* figured by Mc Intosh, which thus resembles the youngest known stages of *G. Esmarki* most of all. From these last, Mc Intosh's specimens only differ in having somewhat more anterodorsal pigment, as also by the presence of the subnotochordal pigment near the end of the tail. As to whether these differences have any great diagnostic importance, I cannot say.

Gadus — or at any rate gadoid — larvæ have several times been described from the Mediterranean as belonging to *G. minutus* (Raffaele, Marion, Holt). These Mediterranean larvæ are quite lacking in yellow-pigment in contrast to the larvæ described by Mc Intosh, which were hatched from artificially fertilised eggs of *Gadus minutus* from the North Sea. From what has been said above (p. 49) concerning the Mediterranean *Gadus* ("le capelan"), it would perhaps not be strange, if its larva had a different appearance from that of the British and northern *Gadus minutus*. With respect to the British gadoid-larvæ without yellow pigment described by Holt (1891, p. 52, pl. VI, fig. 52 and 1897—99, p. 140) and referred to *Gadus minutus*, it must be maintained, that, the only larvæ undoubtedly belonging to the British-northern *Gadus minutus*, which we as yet know, are those described by Mc Intosh and said by him to have yellow pigment.

Description

Amongst the material at hand from Great Britain there are some quite young postlarval stages of a *Gadus*, which must undoubtedly be referred to *Gadus minutus*. As the specimens in question have lain several years in spirit, the pigment has quite disappeared. For this reason, as also that they are otherwise badly preserved, I shall not attempt to figure or describe them, the more so as I have had the most friendly promises of the collection and forwarding of fresh material preserved in formalin.

11½ mm. The end of the notochord is already quite reduced, and there is no portion of the caudal fin now free of rays. Its posterior border is slightly concave. The development of the rays in the fins is already far advanced and these are only connected by a low membrane. The following number of distinct rays were counted: D^1 ca. 5, D^2 ca. 10, D^3 ca. 16, A^1 ca. 17, A^2 ca. 17. The majority of the rays reach out to the margin of the fin. The fins are already fairly distinctly formed (much more so than in *G. Esmarki* of the same size). A^1 is a little longer than A^2, and D^2 fairly high in comparison with what is the case in most of the other species at this size. There are weak indications of true rays in the pectorals; the ventrals are wart-like but distinct. The anus is placed a little distance in front of the developing D^2, between this and D^1. The preanal portion of the body is fairly high and thick in relation to the postanal; the eyes are large (larger than in a *G. Esmarki* of 13 mm.) and very strongly convex, so that they seem to stand well out of the orbits, especially when the animal is viewed from above.

The postanal pigment is very similar to that in *Gadus Esmarki*. There are ca. 7 large, stellate ventral chromatophores, which should rather be called ventrolateral, however, as they are somewhat removed from the marginal line. Posteriorly the row does not reach to the caudal fin and extends anteriorly to near the anus. A similar number of dorsal chromatophores is present; the foremost is placed almost over the pectoral region. Behind the anus the dorsal chromatophores are very distant from one another. The sides are quite lacking in pigment. 3 large, round, occipital chromatophores and a distinct preanal row, which reaches posteriorly to the anus, are also present. The specimen in question was taken on May 27th 1897 in Start Bay near Plymouth.

A large number of pelagic specimens, from ca. 14—23 mm. in length, is present in the collections

from Plymouth (taken e. g. on May 25th 1897 in Start Bay; also a large number of specimens taken with the "Mosquito net trawl" at Plymouth on July 9th 1891), but in many of them the pigment has disappeared (spirit-preservation). In some however it is somewhat preserved. Before passing to the description of the next two developmental stages represented by the two best preserved specimens, I may mention, that the unpaired fins at a size of ca. 13 mm. were practically separated, the embryonic fin between them having disappeared. To judge from the English and other specimens the fin-rays are very fragile and brittle in the early stages.

16 mm. The end of the notochord is quite reduced. The caudal fin is slightly concave; its rays are very fragile. The unpaired fins (even the two anal fins) are separated and already approximate more to the permanent form than in *G. Esmarki* of the same size. D^1 is relatively well-developed and has almost the same height as D^2. A^1 is but a little longer at the base than A^2. The following number of rays was counted: D^1 ca. 10—11, D^2 ca. 18, D^3 ca. 20, A^1 ca. 24, A^2 ca. 21. The ventral fins are still but small, scarcely $^1/_3$ of the diameter of the eye and hardly reach to $^1/_4$ of the distance to the anus, measured from their base. The anus is placed almost in the middle between D^1 and D^2. The foremost part of A^1 reaches a little further forward than the foremost part of D^2 (In a *G. Esmarki* of the same size the foremost part of A^1 was just under the corresponding part of D^2). All the fins were quite lacking in pigment. The eyes are very large and strongly convex. The diameter is considerably greater than the distance from the anterior margin of the eye to the tip of the snout. Pl. III, Fig. 16

The preanal portion of the body is relatively very high and thick. This condition is specially apparent on observing the fish from above, and by comparison with *G. Esmarki* (*G. minutus* is almost "club-shaped" anteriorly). The height at the beginning of the caudal fin is but small, so that the body seems a little narrowed here.

The pigment is so very similar to that in *G. Esmarki*, that I am unable to note any distinctive difference. There is a small number of occipital chromatophores and a distinct row of preanal pigment spots, which reach right to the anus posteriorly. The abdominal pigment is very faint. The postanal pigment consists as in *G. Esmarki* of a relatively small number of large, stellate chromatophores ventrally and dorsally. In the anterior part of the ventral row the chromatophores are denser than further back and than in the dorsal row. The sides are unpigmented.

23 mm. The specimen in question, which comes from Plymouth, was taken near the bottom, but still pelagically. D^1 is now higher than the other dorsal fins. Its posterior portion abuts on the anterior portion of D^2. The following number of rays was counted: D^1 11, D^2 20, D^3 21, A^1 24, A^2 21. A^1 is not much longer at the base than A^2. The two anal fins are quite separated. The ventral fins are not yet so long as the diameter of the eye, they reach scarcely halfway to the anus. All the fins are lacking in pigment. The body is much higher and bulkier in front of the anus than behind this, so that it may be said here as of the previous stage, that the body is club-shaped anteriorly; this is specially apparent when the fish is observed from above. The anus lies under the hindmost part of D^1. The eyes are very large and strongly convex. The distance from the anterior margin of the eye to the tip of the snout is considerably less than the diameter of the eye (ca. $^2/_3$ of the latter). The snout is rounded and the supraorbital region convex. The underjaw extends but a very little way forward beyond the upper. Pl. III, Fig. 17

The pigment is almost as before. The preanal row is still distinct and reaches almost to the anus.

Ventrally there are ca. 12 large, stellate chromatophores behind the anus. These are however not quite ventral, having moved a little upwards from the margin. Between this row of large, stellate

chromatophores and the ventral margin (base of the anal fins) there is now a row of smaller and more closely placed chromatophores. The dorsal pigment is considerably weaker and less constant than the ventral. The sides are unpigmented.

The specimen described is the largest pelagic I have seen. The next larger is ca. 25 mm. long and was taken at the bottom like all the other larger specimens. From the North Sea (43 miles west from Horns Reef lightship, depth 50 m.) 2 specimens are present (ca. $25^1/_2$ and $27^1/_2$ mm. long) taken by Dr. A. C. Johansen from the "Thor" on Sept. 28th 1904. The remaining young stages (under 50 mm.) I have seen, come from Plymouth. Some older bottom-stages (50—100 mm.) are present in my collection from the southern coast of Norway, the Skager Rak, Kattegat, Plymouth and west coast of Ireland.

Pl. III, Fig. 18

25 mm. The caudal fin is somewhat forked. D^1 is somewhat higher than in the previous stage. The following number of rays was counted: D^1 12, D^2 ca. 20, D^3 ca. 21, A^1 25, A^2 20. The form and pigment of the body is essentially as in the previous stage, the dorsal pigment however being denser and more pronounced.

If we observe the animal from the ventral aspect, we see, that the anterior portion of the ventral pigment consists of 3 rows of chromatophores, namely, of a row of somewhat smaller chromatophores in addition to the original large ventral chromatophores, and lastly (nearest the bases of the anal fins), of a very regular and conspicuous row of small, closely placed chromatophores. Further back there are but two rows, the intermediate of the 3 anteroventral rows being wanting here. The row nearest the bases of the anal fins especially is very regular and constant.

$27^1/_2$ mm. A young bottom stage from Plymouth is represented in text-figure 14, in order to show the difference between this species and *Gadus luscus* and *Gadus Esmarki*. We see from it, that *G. minutus* is very different from *G. luscus*, but on the other hand stands much more closely to *G. Esmarki*, from which it is distinguished by the characters already mentioned. The number of rays was found to be the following: D^1 12, D^2 21, D^3 21, A^1 26, A^2 23.

The pigment is not essentially different from that of the previous stage. There is perhaps a little more dorsal pigment, but the sides are still free of pigment. The same 3 rows of anteroventral chromatophores, which were described in the previous stages, are still very distinct. Posteriorly there are also but two rows. The row nearest the bases of the anal fins especially is very regular and fixed. There are some faint pigment spots on the two anterior dorsal fins.

Pl. III, Fig. 19

50 mm. I have drawn the specimen figured, which was taken in shallow water at the bottom in one of the southern Norwegian fjords, in order to show how the sides gradually become overstrewn with pigment. It is still however relatively weak (cf. *G. luscus*), especially posteriorly and ventrolaterally. The unpaired fins are now somewhat, though not very strongly, pigmented, the pigment being most dense in the proximal and anterior portions of the fins. There is a characteristic black streak on the foremost edges of D^1 and D^2. A^2 has practically no pigment.

The fins have assumed essentially the same form as is found in the older fish. The caudal fin is somewhat forked, and D^1 is high. A^1 is somewhat longer than A^2. The difference however is far from being as great as in *G. luscus*. The two anal fins are quite separated. The following number of rays was found: D^1 13, D^2 23, D^3 21, A^1 27, A^2 23.

The ventral fins are now much longer than the diameter of the eye and reach to the anus. The latter is placed under D^1 (somewhat behind its centre). The form of the body is somewhat changed since the preceding stage, the greatest height now being a little further back; the preanal portion of the body is still however relatively very bulky. The eyes are large, yet relatively smaller than in the

previously described stages. The diameter is a little greater than the distance from the anterior margin of the eye to the tip of the snout. This is rounded, and the upperjaw reaches almost as far forward as the underjaw (in contrast to *G. Esmarki*). A large and strong barbule is now present.

To describe and figure still older stages of *G. minutus* seems to me superfluous. Confusion with *G. luscus* is to my mind, in accordance with what has already been said, quite excluded. From *G. Esmarki* *G. minutus* is distinguished in the youngest bottom-stages especially by the form of the body and snout, and by the size of the barbule[1]. The caudal fin is less forked, and D^1 and D^2 meet. The number of rays in A^2 will often facilitate the separation.

Material

Whilst older postlarval stages (from ca. 12 mm.) are sufficiently well-known, we still lack acquaintance with the youngest stages of this species.

Verification of the determinations

In the foregoing, we have seen how to identify the pelagic young of most of the *Gadus*-species There still remain three, viz. *G. minutus*, *G. luscus* and *G. Poutassou*. In addition, we must take into consideration the small *Gadiculus argenteus*, which occurs in deep water and has recently often been referred to the *Gadus*-genus, and which, whether this is wright or not, has 3 dorsal and 2 anal fins like the *Gadus*-genus.

The number of rays in the anal fins and D^2 in *G. luscus* and *minutus* as well as *Gadiculus* can be seen from the following:

	G. minutus			*G. luscus*				*Gadiculus argenteus*		
	A^1	A^2	D^2	A^1	A^2	D^2		A^1	A^2	D^2
Krøyer	25—28	21—23	19—25				Günther (1874)	17	16	13
Day	25—29	17—24	19—25	27—32	17—20	19—20	Vaillant (1888)	18	15	14
M'Intosh (1888)	26—28	19—22	21—25	31—33	20—21	22—26	Collett (1901)	12—17	15—19	11—12
Lilljeborg	25—29	17—24	19—25	25—34	17—21	20—28	Author	17	15—17	11—12
Author	26—29	20—21		30—34	19—22					

Taking all these together and including those given on p. 36 we obtain the following list:

	A^1	A^2	D^2
G. aeglefinus	21—27	20—25	20—24
G. merlangus	30—38	20—25	18—25
G. Esmarki	26—30	24—30	22—26
G. Poutassou	34—41	20—27	12—14
G. minutus	25—29	17—24	19—25
G. luscus	27—34	17—21	19—28
Gadiculus argenteus	12—18	15—19	11—14

The various *Gadus*-young, I have determined as *G. minutus*, formed a series which was characterised, in addition to the unpigmented sides as in *G. Esmarki*, by the bulkiness of the preanal portion of the body, so that the trunk anteriorly was almost club-shaped, whilst posteriorly it was slender.

[1] Collett)1875, p. 109) states, that the young of *Gadus minutus* of 60—70 mm. are commonly taken in herring nets in Christiania Fjord during the autumm, and he maintains, that they greatly resemble *Gadus Esmarki* at this stage, but can be distinguished as a rule from this species, "by the longer and thicker barbule, and the rounded snout".

Further the size of the eyes was conspicuous. The two anal fins, whose lengths were not very different, were quite separated, and the anus was placed under the posterior third of D^1. The number of rays in 3 specimens (23—27½ mm.) was as follows: A^1 25, A^2 20, D^2 ca. 20; A^1 26, A^2 23, D^2 21; A^1 25, A^2 21, D^2 (?). These numbers as well as the position of the anus and the respective lengths and form of the fins showed, that the only one of the 4 species remaining which came in question was *G. minutus*. The smallest stages determined as belonging to this species, where the number of rays could not yet be counted, has been referred to *G. minutus* and not to *G. Esmarki*, which it closely resembles, on account of the very large size of the eyes, the thickness of the preanal portion of the body and the earlier development of the fins, especially of D^1. Most of the specimens examined, also, come from Plymouth, where *G. minutus* is common but *G. Esmarki* quite lacking or at any rate rare, so far as known.

Occurrence within the region under observation

Pelagic young of *G. minutus* were not found within the region investigated by the "Thor". Nor have its pelagic young been taken hitherto in the Danish waters within the Skaw.

2nd Group (end of the tail unpigmented)

9. *Gadus luscus* Linné; Pout or Bib

Principal literature and figures:

Larval stages: Cunningham (1889—90, p. 46, fig. 35)?; Holt (1897—99, p. 138—140)?; Heincke & Ehrenbaum (1900, p. 254, pl. X, fig. 21)?. — Postlarval stages: Holt (1897—99, p. 141).

Nothing certain is known concerning the larval stages of the pout, though it is probable, that the larva figured by Heincke & Ehrenbaum, for example, belongs to this species. The hatching of the artificially fertilised egg must decide the question. On the other hand, the postlarval specimen from Plymouth of 18 mm. in length described by Holt (l. c. p. 141), which I have been able to examine through the kindness of Dr. E. J. Allen, is certainly a *G. luscus*.

The whole of my material of *G. luscus* young under 50 mm. in length comes from the English Channel. Examination of this material has, almost to my surprise I may say, led to the result, that *G. luscus*, right from the youngest known pelagic stages, is extremely different from *G. minutus*, which occurs side by side with it in the English collection. The examination has further shown, that *G. luscus*, right from the youngest known pelagic stages (and not least in these) is a specially well-marked species, which is very easily distinguished from all other *Gadus*-species.

Description

11 mm. The smallest specimen I have seen is 11 mm. long and was taken on June 17th 1897 on the surface in the neighbourhood of Plymouth. As it is quite lacking in pigment, for the good reason that it has lain some years in spirit, I have not been willing to figure it. The form is characteristic, the body being unusually high both in front of and behind the anus, and narrowing quite abruptly about the anterior portion of D^3 and A^2, so that the height at the commencement of the caudal fin is obviously small in comparison with that of the remaining portion of the body.

The caudal fin is already far advanced in development and no longer has any part free of rays. It is broad posteriorly, narrow anteriorly, and on the whole distinctly more formed than in other species at this size. Further, the free end of the notochord is strongly bent upwards and already much reduced. The three dorsal fins are already distinctly formed, the embryonic fin opposite the interspaces between

the developing fins being distinctly lower than opposite the fins. On the other hand, the separateness of the two anal fins cannot be recognised in this way, the embryonic fin not being lower here opposite the interspace between the two developing fins. The difference between the dorsal and anal fins in this regard is quite unique within the *Gadus*-genus. The following number of rays was found: D^1 ca. 7, D^2 ca. 15, D^3 ca. 16, A^1 ca. 20, A^2 ca. 15, but some of these rays are still but little distinct. The central rays in the developing fins reach out to the margin of the embryonic fin. D^1 is lower than D^2, but still unusually high in relation to the size of the fish. The ventral fins are wart-like. The anus lies a little behind the middle of D^1.

As mentioned, pigment was quite lacking.

18 mm. The present specimen is the same as that described by Holt (1897—99, p. 141) and referred by him to *G. luscus*. The body is extremely high, but narrows very abruptly posteriorly about the beginning of D^3 and A^2, so that the form is thus very different from that of all other *Gadus*-species. The caudal fin has a broad, straight posterior border. It is quite separated from D^3 and A^2. D^1, which is much higher and more pointed than the other unpaired fins, is quite separated from D^2. On the other hand, something still remains of the embryonic fin between D^2 and D^3, and the two anal fins, though the boundary between them can be detected by a depression in the margin, are still fully connected, so that some difficulty is experienced in determining to which of the two fins the rays on the boundary between them belong. The following number of rays was found: D^1 12, D^2 22, D^3 22, A^1 32, A^2 20. The ventrals are still small, not so long as the diameter of the eye. The anus lies almost under the middle of D^1. Pl. III, Fig. 20

Some very apparent, deep-black and well-defined pigment spots are present on the distal ends of D^1, D^2 and A^1 (cf. *G. aeglefinus* and *pollachius*), by means of which condition *G. luscus* i distinguished at a glance from *G. Esmarki* and *minutus*.

The postanal pigment of the body is also very characteristic. The dorsal and ventral pigment consists each of a well-marked dark streak, formed by a row of concurrent chromatophores, which reach posteriorly to the middle third of D^3 and A^2 respectively, where they quite suddenly come to an end. The ventral streak extends slightly further back than the dorsal (in contrast to *G. Poutassou*). Anteriorly the dorsal streak decreases gradually in strength, the chromatophores becoming separated here. The dorsal pigment consists therefore of two portions: a weaker row anteriorly of separated chromatophores which reach almost to the occipital pigment, and a compact black streak posteriorly, which begins a little behind the middle of D^2 and ends about the end of the anterior third of D^3. The ventral streak consists of concurrent chromatophores along practically its whole length, and as it reaches anteriorly almost to the middle of A^1 (posteriorly a little beyond the end of the anterior third of A^2), it is longer than the dorsal streak (in contrast to *G. Poutassou*). In addition to the dorsal and ventral pigment, numerous, fairly large chromatophores are present dorsolaterally and ventrolaterally. This pigment also ends abruptly posteriorly at the same place as the dorsal and ventral streak, and the pale, unpigmented end of the tail thus stands out in very sharp contrast to the remaining pigmented portion of the body[1]. The mediolateral region is free of pigment and thus shows as a fairly well-defined, narrow, pale longitudinal belt along the middle of the sides.

20½ mm. The specimen of 20½ mm. in length figured is at essentially the same stage as that of 18½ mm. The greatest height lies some distance in front of the anus (almost at the base of the pectoral fins), and the back is strongly arched. Pl. III, Fig. 21

[1] The boundary of the dorsolateral and ventrolateral pigment is a line running obliquely to the longitudinal axis of the fish through the posterior points of the dorsal and ventral streaks.

The first portion of the body behind the anus is still particularly high and narrows abruptly towards the end of the tail. A^1 and A^2 are still joined. The' ventrals are now longer than the diameter of the eye, but do not reach to the anus. In A^1 there were 31 rays, in A^2 21. The caudal fin is quite square posteriorly. The pigment on the fins and body is as in the previous stage and requires no further description. The preanal pigment reaches posteriorly to the anus. This lies almost under the middle of D^1.

Pl. III, Fig. 22

24 mm. This specimen is a young bottom-stage, taken on June 13th 1902 in Cawsand Bay (near Plymouth). The greatest height of the body is still some distance in front of the anus, but posteriorly the body does not narrow quite so abruptly as in the previous stages. The ventral fins reach quite to the anus. The pigmentation and form of the fins are almost as in the preceding stages, and the fin pigment is still extremely well-marked. On the other hand the pigment of the body extends somewhat further posteriorly, the dorsal and ventral streaks now reaching beyond the middle of D^3 and A^2 respectively, and the end of the tail is thus no longer so sharply marked off from the remaining portion of the body. The dorsolateral and ventrolateral pigment do not reach much further back than before, and the mediolateral region is still a narrow unpigmented belt. There is some pigment even on the end of the tail, but it is not on the surface.

28 mm. A young bottom-stage, taken on Aug. 23rd 1897 in Cawsand Bay near Plymouth, is represented on page 49, Fig. 13, along with a specimen of *G. minutus* (Fig. 14) of the same size, in order to show the difference between the two species. (See explanation of figures, Fig. 13 and 14). The greatest height of the body lies now almost at the anus, which is placed under the anterior third of D^1. The ventral fins reach some distance beyond the anus. The two anal fins are connected as previously. The posterior border of the caudal fin is straight across. The anterior parts of D^3 and A^2 are approximately parallel. D^1, D^2 and A^1 are strongly pigmented at their distal ends.

The pigment on the sides is even denser and more widely distributed than before. The mediolateral region is now beginning to show pigment also, and the pigment on the sides extends further back than before. The greater part of the sides between D^3 and A^2 is still, however, lacking in pigment.

Pl. III, Fig. 23

34 mm. This is a young bottom-stage, taken on June 15th in Cawsand Bay near Plymouth. The height of the body in front of the anus is now relatively less than before, and the body behind the anus likewise narrows less suddenly than previously. The anus lies under the anterior portion of D^1. A^1 and A^2 are joined. The ventrals reach to behind the anus. The pigment on the fins and sides is almost as in the previous stage. A distinct barbule is present.

Pl. III, Fig. 24

50 mm. The present specimen, taken in Cawsand Bay near Plymouth on July 1st 1904, is figured in order to show how the pigment has now spread entirely over the sides, and further, is much denser than before. The unpaired fins also are covered by diffuse pigment. The two anal fins are joined. A^1 is much longer than A^2. The anus lies under the anterior portion of D^1. The ventrals now extend far beyond the anus. A large barbule is present. The greatest height is 22% of the total length, and is thus distinctly greater than in *Gadus minutus* of the same size[1]. *G. luscus* also differs from the latter species in e. g. the position of the anus, the length of A^1 in relation to A^2, the junction of these two fins, the form of D^3 and A^2 etc. In A^1 there were 36 rays, in A^2 21.

[1] In *Gadus minutus* of 50 mm. the greatest height of the body was found to be $18^1/_2 - 19$% of the total length.

Material

The developmental history from the stages of 11 mm. in length and onwards is sufficiently well-known from the Plymouth material to hand. Stages less than 11 mm. are as yet unknown, but will probably be recognised without difficulty by means of the postanal pigment streaks and the great height of the body.

Verification of the determinations

In the collections of the pelagic and young bottom-stages of *Gadus*-species from Plymouth, there was a large number of specimens in different stages of development, which were distinguished at first sight by their extremely great bodily height, and further by the well-marked dorsal and ventral streaks of pigment. By means of these characters I was easily enabled to establish a developmental series of this species, which was distinctly different from all *Gadus*-species hitherto described, and must therefore belong to *G. luscus*, *Poutassou* or *Gadiculus argenteus*. From the number of rays given on page 53 we see, that the two last named species are well characterised by the low numbers in D^2 and A^1 respectively, so that the matter could easily be decided by reference to the rays. In 3 postlarval specimens (18, 20, $20^1/_2$ mm.), which had undoubtedly attained the full number of rays, I found the following:

A^1	A^2	D^2
32	20	22
32	21	22
31	21	?

It thus appeared, that the young fish in question belonged to *Gadus luscus*. The older specimens of the developmental series also agreed with this species in every respect (height of the body, position of the anus, the junction of the two anal fins etc.).

Occurrence within the region under observation

The postlarval young of *Gadus luscus* are not found within the region investigated by the "Thor", and up to the present are only known on the whole from the English Channel.

A number of large specimens of *G. luscus* are preserved in the Zoological Museum at Copenhagen, coming according to the label from the "Atlantic Ocean south from Iceland", and brought by the captain of a trawl-steamer. It seems to me somewhat improbable, that these specimens should really come from Iceland. The species has otherwise not been found north of the Shetlands (it is never found on the coast of Norway), and there can assuredly be no talk of a pelagic life which might take this shallow-water species out over the oceanic depths. It is opportune to remark, that the same collection, with the label "Atlantic Ocean south from Iceland", contains in addition to *G. luscus* 2 other more southerly species, whose occurrence at Iceland might also cause some surprise. It seems best, therefore, until further investigation, to consider the discovery of *G. luscus* at Iceland as very doubtful.

10. ***Gadus Poutassou*** (Risso), **Poutassou**

Principal literature and figures:

Larval stages: undescribed. Postlarval stages: undescribed.

Nothing whatsoever has been known hitherto concerning the early developmental history of this characteristic species, which one can understand, however, on learning, that the tender fry of *G. Poutassou* have not been taken by the "Thor" in the neighbourhood of the coasts, but up to the present only in the open sea over the great oceanic depths. In the foreign collections, I have investigated, I have not found the young of this species.

Description

6 mm. The smallest specimen of this species, I have seen, measured 6 mm. and was taken at "Thor's" Station 100, on May 22nd 1904 (see page 62). In form it resembles most closely a young whiting of this size and thus shows no special character in this regard. The notochord is quite straight. Indications of the interspinous regions are seen on the caudal fin as faint, non-transparent parts below and above, but these have no sharp boundaries and fin-rays are still wanting. Indications of the interspinous regions are still lacking in the other unpaired fins. The pectorals are fan-shaped folds with embryonic rays, and ventrals are quite absent.

The pigmentation is specially characteristic. The occipital pigment consists of a large number of large, well-marked, closely placed chromatophores. The abdominal pigment is likewise well-marked and consists of large, stellate chromatophores. On the other hand, the preanal pigment is but weak, only a single chromatophore being present. The postanal pigment is very apparent and consists only of a dorsal and ventral streak, both specially well-marked and ending very abruptly posteriorly, so that a large part of the caudal fin remains quite unpigmented. The ventral streak, which is much shorter than the dorsal, begins some distance behind the anus and ceases already before reaching to the middle of the postanal portion of the body. The dorsal streak, which reaches a good distance more posteriorly than the ventral, extends anteriorly past the anus to the pectoral region, but is not so well-marked in its preanal as in its postanal portion. In this youngest stage the sides are quite lacking in pigment.

Pl. III, Fig. 10

Fig. 16. *Gadus Poutassou* (Risso). Young postlarval stage. "Thor" Station 87, 2nd June 1903. 61° 40′ N., 13° 33′ W., Depth: more than 1000 fathoms. Atlantic Ocean south from Iceland. Natural size: $6^2/_3$ mm.

$6^2/_3$ mm. This stage is but little more advanced in development than the preceding. Faint indications of the interspinous regions are seen in A^2 and D^3, however, and the first traces of rays can be detected in the caudal fin. Some few dorsolateral and ventrolateral pigment-spots are present on the sides between the two streaks. In the living specimens there is some yellow pigment on the head and lateral aspects anteriorly, as far as the end of the postanal streaks, but this yellow pigment is extremely weak.

Pl. III, Fig. 11

7 mm. The notochord is still straight. Indications of rays in the caudal fin are still very faint. Extremely faint indications of the interspinous regions are seen in A^1 and D^2. There is somewhat more preanal pigment here than usual. Except that a little more dorso- and ventrolateral spots are present, the pigment is as in the previous stage.

Pl. III, Fig. 12

$8^1/_2$ mm. The volume of the body has considerably increased since the foregoing stage. The end of the notochord is very slightly bent upwards, and distinct signs of rays are now present below and above in the caudal fin. Indications of the interspinous regions are to be seen in all the unpaired fins (also in D^1).

The occipital pigment is dense and the abdominal pigment well-marked. The preanal pigment is almost entirely absent. The dorso- and ventrolateral pigment is now very dense and well-marked, but the mediolateral region is unpigmented and shows as a pale narrow belt centrally on the side (cf. *G. merlangus* and *luscus*). Posteriorly the dorso- and ventrolateral pigment is limited by a line through the posterior points of the dorsal and ventral streaks, and the boundary is sharp, so that the pale un-

pigmented end of the tail stands out in very sharp contrast to the pigmented portion of the body. The latter, in contrast to the end of the tail, has a yellowish tinge in living specimens due to small, scattered points of yellow chromatophores. Both the dorsal and ventral streaks are very well-marked. The former reaches posteriorly almost to the end of the developing interspinous region in D^3, the latter only to about the middle of the same region in A^2. The unpigmented end of the tail is thus cut off obliquely just as in *G. luscus*, but in the opposite direction (cf. Figs. 12 and 21 of Pl. III).

10¼ mm. The end of the notochord is somewhat bent upwards, and the greater part of the caudal fin now shows rays. The developing interspinous regions in the other unpaired fins are unusually high and short, so as to have almost a triangular form. D^1 and D^2 are situated close to one another, but D^2 and D^3 are separated by an unusually large interspace. The rays are still indistinct, but their position is indicated by faint non-transparent regions in the embryonic fin. The anus lies under D^1. The ventrals are very small, wart-like. The pigment is almost as in the previous stage and is still very sharply bounded posteriorly. A narrow mediolateral belt is still free of pigment. Pl. III, Fig. 13

11 mm. The end of the notochord is strongly bent upwards and the length of its free portion is only ca. 1/6 of the distance from its posterior point to the posterior border of the caudal fin. Rays are also present in the central portion of the caudal fin. In D^2, which is very short and separated by a large interspace from D^3, there are only ca. 6, in D^3, which is much longer, ca. 12 developing rays. A^1 is lower and longer than A^2. A^2 has ca. 16 developing rays. The ventrals are still wart-like and very small. The anus lies under D^1. The pigment on the sides has spread further back towards the end of the tail since the previous stage, but by far the greater part of this is still unpigmented. The dorsal and ventral streaks are still very apparent.

13 mm. The free end of the notochord is almost entirely reduced. The caudal fin is slightly concave. The unpaired fins are bound by the embryonic fin, which is still broad all round, but the central rays in the various fins reach out to the margin. In D^1 there were ca. 5, in D^2 ca. 6, in D^3 ca. 16 rays. D^1 and D^2 are both very short and close together, but D^2 is separated from D^3 by a large part of the embryonic fin free of rays, where even indications of the interspinous region are wanting. Ca. 25 rays were counted in A^1, but there are also parts anteriorly and posteriorly, which are very low, where the rays are not yet formed. In A^2 there are ca. 16 developing rays. There is a black chromatophore on each of the interspinous rays in D^3 and A^2. The ventrals are no longer wart-like, though still extremely small, not 1/8 of the diameter of the eye. The anus lies under D^1. Pl. III, Fig. 14

The pigment on the sides is very dense, but a lighter mediolateral belt can still be detected. Though the dorsal and ventral streaks and especially the dorso- and ventrolateral pigment have spread further back, the contrast between the pale end of the tail and the pigmented portion of the sides is still great. Both streaks are still very distinct. The ventral streak is short, beginning a little in front of A^2 and ending before the latter does.

16 mm. The caudal fin is somewhat concave and its corners are rounded. The embryonic fin has not yet disappeared between the unpaired fins, but is now low however. D^1 and D^2 are close together, whereas D^2 and D^3 are separated by a large interspace without rays or interspinous rays. A^1 is much longer (and lower) than A^2. The following number of rays were counted: D^1 ca. 7, D^2 ca. 10, D^3 ca. 20, A^1 at least 27, A^2 ca. 21. With exception of the interspinous rays in D^3 and A^2, the fins are still quite lacking in pigment. The ventrals are very small, scarcely 1/4 of the diameter of the eye, The anus lies under the anterior portion of D^1. Pl. III, Fig. 15

The pigment on the sides extends almost to the beginning of the caudal fin, and the end of the

tail is thus still free of pigment. Whilst the dorsal streak is still very distinct, the ventral is weaker. The sides are entirely overstrewn with pigment, which also applies to the mediolateral region. The anteroventral and the anteroventrolateral regions however are still without pigment.

The specimen described of 16 mm. in length was the largest postlarval specimen taken during 1903 and 1904; but later, in May and June 1905, the "Thor" has also taken the older postlarval stages of *Gad. Poutassou* in quantities over great depths between Iceland and Scotland and west from the British Isles. The postlarval developmental history of this species is therefore now completely known. I shall give here a description of 3 older stages (21, 25½, 32 mm.). I must however postpone publishing figures of these older stages to the 2nd. portion of this work, as the plates have been finished and reproduced for some time.

21 mm. The free end of the notochord is reduced. The caudal fin is forked and rounded at the corners. The unpaired fins are now almost separated; D^1 has about the same height as D^2. There is a considerable distance between D^2 and D^3, almost as great as the length of D^2 at the base. A^1 is very long and low. The anus lies under the foremost part of D^1. In D^1 there are 11—12 rays, in D^2 12, in D^3 at least 23, in A^1 at least 32, in A^2 at least 23. The ventral fins are very short, scarcely ⅓ of the diameter of the eye.

The pigment on the sides is about the same as in the preceding stage (16 mm.), extending posteriorly to the beginning of the caudal fin. The light mediolateral region can still be detected in some specimens of this size. The dorsal streak is well-marked and reaches posteriorly almost to the beginning of the caudal fin. The short ventral streak is much weaker, but can still be detected. It does not extend so far back posteriorly as the dorsal streak, and pigment is also lacking anteroventrally. The fins are unpigmented.

There is but little coloured pigment in living specimens. Some yellow points are present on the sides between the large chromatophores, but are so widely separated from one another, that they merely give the fish a very faint yellowish tinge. The abdominal region has already the first weak signs of a silvery sheen.

The specimen described was taken at the "Thor"s Station 63, on May 30th 1905 (59° 49′ N., 8° 58′ W., depth: 1150 meters), in a haul with the young-fish trawl, 65 meters of wire being out.

25½ mm. The caudal fin is deeply forked. The unpaired fins are quite separated. D^1 is a little higher than D^2. The ventral fins are scarcely half as long as the diameter of the eye and are far from reaching half-way to the anus. This lies under the anterior edge of D^1. The following number of rays was counted in the dorsal and anal fins: $D^1 = 11$, $D^2 = 11—12$, $D^3 = 22$, $A^1 = 38$, $A^2 = 26$.

The pigment extends further back than in the preceding stage, but a portion at the end of the tail is still without pigment. The dorsal and ventral streaks are almost as in the preceding stage, but the latter is even fainter.

In these stages, where the end of the tail is beginning to be covered by pigment, *G. Poutassou* reminds one not a little of *G. merlangus*, from which however it is easily distinguished by the large interspace between D^2 and D^3. Further, the chromatophores on the sides in *G. Poutassou* are larger and of more regular star-shape; finally, the postanal ventral pigment in contrast to the condition in the whiting is limited to a short row of chromatophores, the anteroventral region being unpigmented.

The specimen described was taken at the "Thor"s Station 63, on May 30th 1905 (59° 49′ N., 8° 58′ W., depth: 1150 meters), in the young-fish trawl with 65 meters wire out.

32 mm. The body is slender and elongated with the greatest height lying in front of the anus. The form is most like that of the cod (*G. callarias*), but is somewhat more slender than in the latter.

The caudal fin is forked posteriorly. D^1 is now higher than the other dorsal fins. The large interspace between D^2 and D^3 is very obvious. A^1 is extremely long, much longer than A^2. The anus lies immediately in front of the beginning of D^1. The length of the ventrals is quite $2^1/_2$ mm.; they are somewhat larger than the diameter of the eye and scarcely reach to the anus. The fins are practically lacking in pigment. The following number of rays were counted: $D^1 = 12$, $D^2 = 12$, $D^3 =$ ca. 23, $A^1 = 37$, $A^2 = 27$.

The pigment on the sides is dense, and the end of the tail is now entirely pigmented. The dorsal streak is well-marked as usual, whilst the short ventral streak is fainter. The pigment on the lateral aspects is not so dark as in younger stages. The abdominal region is now quite silvery in appearance, and the lateral aspects anteriorly have also begun to show a very faint sign of a silvery sheen.

This specimen was taken at the "Thor"s Station 64, on May 30th 1905 (59° 17′ N., 7° 29′ W., depth: 895 meters), in the young-fish trawl with 65 meters wire out.

$79^1/_2$ mm. The specimen of this size resembles the adult fish so much, that there is no need to describe it closely. The pigment now covers the greater part of the sides; the ventral aspect however is almost free of pigment. Most of the pigment is on the dorsal aspect. The dorsal fins and caudal fin are densely pigmented, the anal fins but little. The caudal fin is strongly cleft and the ventral fins are short; they reach scarcely to the anus.

Material

The whole postlarval developmental history of *G. Poutassou* can be made out clearly from the "Thor"s material, which embraces all postlarval stages.

Verification of the determinations

The "Thor"s discovery of delicate *Gadus*-young on the surface over the great oceanic depths south from Iceland was very remarkable. The pigmentation and other features made these young very obviously different from all other known species of the genus. Only two species to which they might belong could come in question, after it had been determined that they had 3 dorsal and 2 anal fins, namely *Gadus Poutassou* and *Gadiculus argenteus*. By counting the rays in A^1 in one the larger specimens (16 mm. long), I found, that there were at least 27 already, and *Gadiculus*, which has only a very small number of rays (12—18) was thus excluded. That their determination as *G. Poutassou* was correct, was further shown, im part by the anus being placed far forward, in part because D^2 was very short and separated from D^3 by a large interspace. Finally, the number of rays in the older postlarval specimens taken during 1905 (2—5 cm. in length) showed, that only this species could be in question.

Occurrence within the region under investigation

As already mentioned, the postlarval young of *G. Poutassou* have hitherto been found only in the open sea. I may mention here the hauls in which they were taken during 1903 and 1904[1].

1903.

"Thor" Stat. 87. 2nd June 1903. 61° 40′ N., 13° 33′ W. Depth: more than 1000 fathoms. Young-fish trawl on the surface, 20 min.: 9 *Gadus Poutassou* ($6^2/_3$—11 mm.).

[1] In 1905 (May and June) the postlarval young of *G. Poutassou* were taken in quantities, as already mentioned, at numerous stations in the open sea between Iceland and Scotland and west of the British Isles; but this material has not yet been fully worked out, so that I am unable to give a complete list of the occurrence of the young as for the preceding years. This will be given later as also the figures of the older postlarval stages.

"Thor" Stat. 88. 2nd June 1903. 61°30′ N., 13°33′ W., Depth: $\frac{1}{1900}$ meters. Young-fish trawl on the surface, 10 min.: 6 *Gadus Poutassou* (6½—11 mm.).

"Thor" Stat. 91. 3rd June 1903. 61°30′ N., 17°08′ W., Depth: more than 1000 fathoms. Young-fish trawl on the surface, 10 min.: 2 *Gadus Poutassou* (10—13 mm.).

"Thor" Stat. 92. 3rd June 1903. 61°31′ N., 19°05′ W., Depth: more than 1000 fathoms. Young-fish trawl on the surface, 10 min.: 1 *Gadus Poutassou* (16 mm.).

1904.

"Thor" Stat. 100. 22nd May 1904. 61°21′ N., 10°59′ W., Depth: ca. 1300 meters. Young-fish trawl on the surface and with 70 meters wire out. 4 *Gadus Poutassou* (6—8¼ mm.).

In comparison with the size of the region over which the "Thor"s investigations round Iceland extended, it is only within a relatively limited area south from this island that the postlarval young of *G. Poutassou* have been found, and what is specially remarkable on the surface out over the great oceanic depths, both in 1903 and 1904. I have no doubt, therefore, that *G. Poutassou* is a pelagic fish in much higher degree than any other *Gadus-species*, which is also indicated by its elongated, slender form. Further, previous investigations also point in the same direction. I may mention the principal ones known to me.

(1) "Thor"s Station 230, 3rd Aug. 1904; 63°10′ N., 7°31′ W., depth: 1090 meters, in a haul with the young-fish trawl (70 meters wire out); 1 *G. Poutassou* (length: ca. 8 centimeters).

"Thor"s Station 283, 31th Aug. 1904; 63°20′ N., 20°49′ W., depth: 124 meters, in a haul with the young-fish trawl (100 meters wire out, the trawl has thus probably fished in less than 50 meters depth); 8 *G. Poutassou* (length: 13, 13, 13, 13, 13½, 13½, 14, 16 centimeters).

These two hauls in conjunction with others, taken at the same time on the surface without giving any *G. Poutassou*, show, that whilst the delicate fry of *G. Poutassou* are to be found on the surface, the older stages seek the lower water-layers, which is also in agreement with the condition found in most other *Gadus*-species. That it may also occur on the surface, however, is shown by the following observations.

(2) On the cruise of H. M. S. "Beskytteren" between Iceland and the Færoes in the beginning of September 1904 a *G. Poutassou* (length: 10·3 cm.) was washed up on deck by a high sea (62°25·5′ N., 8°37′ W.). (Reported by the zoologist of "Beskytteren", Cand. Gemzøe).

(3) Young specimens of *G. Poutassou* of 14 cm. in length were taken during the cruise of the Norwegian investigation-steamer "Michael Sars" from Norway (Aalesund) to Iceland at the end of July 1900, at Station 9 (north from the Færoes, depth: 1962 meters) in the pelagic net and in the stomachs of cod caught on floating lines (Hjort 1901, p. 14).

(4) Holt and Calderwood (1895, p. 430) state, that a large shoal of young *G. Poutassou* was observed on July 10th 1890, 34 miles from Achill Head (off west Iceland, depth: 175 fathoms) on the surface. Some of them taken in a large pelagic net measured between 5½ and 6 inches (ca. 14—15 centimeters).

These observations prove with certainty, that the young *G. Poutassou* (up to 15 centimeters) are often swimming pelagically even over great depths. I am not in a position to give any direct proof, that the adult fish also lead a pelagic life, but according to our present knowledge, the repeated discovery by the "Thor" of the tender fry (mostly 6—9 mm.) on the surface over great depths south from Iceland, far from the coasts and not in the neighbourhood of these, seems difficult to explain except on the supposition, that the older *G. Poutassou* are also able to live pelagically. There is also the striking circumstance, that the young stages, so far as I have been able to determine, are wanting in all the collec-

tions[1] of various countries, where however the young of the coastal *Gadus*-species are represented in quantities. In connection with the question of the pelagic life of *Gadus Poutassou* it may lastly be mentioned, that this species has an unusually wide geographical distribution, occurring right from the Mediterranean (from which I have seen some specimens) to Iceland. Concerning its distribution near Norway COLLETT (1875, p. 110) states, that it is "paa de fleste Steder alm. ved de sydlige og vestlige Kyster op til Polarcirkelen" ("at most places common along the southern and western coasts up to the Polar Circle").

Remarks on the developmental history and pigment of the species of the second main group (*G. aeglefinus, G. merlangus, G. Esmarki, G. minutus, G. luscus, G. Poutassou*).

The developmental history of the species of the second main group does not show the homogeneity, which is found in the first main group. This is readily comprehensible, seeing that the second group is composed of less homogeneous units in systematic regard.

The haddock (*G. aeglefinus*) stands apart from all other *Gadus*-species in its developmental history. The extremely plump, short form in the earliest stages, the early and strong development of the paired fins, and the early and well-marked pigmentation of these fins are unique within the *Gadus*-genus. The pigmentation of the body is also very different from the rule, which is, that the pigment on the sides behind the anus develops from the postanal dorsal and ventral rows of chromatophores, from which it gradually grows inwards towards the mediolateral region so as finally to cover the sides completely. In the haddock on the other hand it is in great part the anterodorsal pigment characteristic of this species with its anterodorsolateral branch (see Pl. II, Fig. 13 and 13a), which forms the point of departure for the development of the pigment on the sides.

Of the remaining species belonging to this group the poor cod (*G. minutus*) and Norway pout (*G. Esmarki*) obviously stand very close to one another in their developmental history, so close indeed, that there is sometimes no small difficulty in distinguishing one from the another in the early postlarval stages. The pigment is remarkable for the relatively few, large stellate chromatophores composing the dorsal and ventral rows, and in that the lateral aspects remain much longer unpigmented than in other *Gadus*-species (at a length of 30 mm. the greater part of the sides is still without pigment). The fins also receive their pigment unusually late. The whiting (*G. merlangus*) seems to come nearest to *G. minutus*—*G. Esmarki*; in the earliest stages its pigment closely resembles that of these two species, but it differs considerably from these, in that the sides are soon covered by pigment, as is the case also in *G. luscus* and *G. Poutassou*. The two species last named each stand somewhat isolated. *G. luscus* is very characteristic from its great height of body and the pigment streaks in the younger postlarval stages; further, from the junction of A^1 and A^2, which, in contrast to the condition in all other *Gadus*-species, is not altered but persists even in the adult fish. That it is incorrect to place *G. luscus* with *G. minutus* as two very closely allied species, is shown very clearly by the developmental history of these two species, the great difference being not least apparent in the youngest known stages. *G. Poutassou* is remarkable for its extremely short 2nd dorsal fin and the succeeding large, rayless interspace between the 2nd and 3rd dorsal fins in addition to its postanal pigment streaks.

[1] The smallest specimen known to me is one of of ca. 8 cm. preserved in the Zoological Museum at Christiania. Of such young stages the Museum owns but this one. (Kindly communicated by Professor R. COLLETT in a letter).

Appendix

Gadiculus argenteus Guichenot, **Silver cod**

Principal literature and figures:

Larval og postlarval stages: undescribed. Young stages: Holt & Calderwood (1895, p. 435).

We have thus completed the description of the young of the true *Gadus*-species occurring in the Atlantic Ocean. There still remains *Gadiculus argenteus*, a small gadoid practically worthless in economic regard. To ascertain its young, however, is of considerable importance for this work, not least because there might be a fear of its being confused, so long as it remained unknown, with the young of species more important economically, as, like the true *Gadus*-species, it has 3 dorsal and 2 anal fins. Most authors in recent years have referred it to the *Gadus*-genus (cf. Collett, 1901, where all the literature is given). There seems to me reason, however, for continuing to hold it separate from the true *Gadus*-species (e. g. the pits on the head, the form of the mouth, position of the pectorals etc., finally, the pigmentation in the youngest stages also, which is very different from what we find elsewhere in the *Gadus*-genus), but I shall not enter further upon the question here, where the main purpose as mentioned is to determine, how far the young may be confused with the young of the economically important *Gadus*-species.

My material consists of a number of young specimens, the smallest of which is ca. 41 mm. long. They were all taken in the trawl at the bottom in 199 fathoms off the west coast of Ireland, and have been kindly sent me by the director of the Irish fisheries investigations, Mr. E. W. L. Holt. As the material was placed in formalin, the pigment is well-preserved.

Description

Pl. III, Fig. 25

41 mm. The body is very bulky in front of the anus, much higher and thicker than behind the anus, from which it narrows off evenly towards the tail. It is thus distinctly club-shaped anteriorly. The mouth is specially large, and the lower jaw extends forward in front of the upper. The size of the eyes greatly exceeds that of any *Gadus*-species. The diameter is 4 mm. or just as large as the height of the body at the beginning of D^3 and A^2. The peculiar deep pits, which characterise the species to such a high degree, can already be seen on the head. The distance of the anus from the end of the snout is scarcely 17 mm., and the anus lies under the posterior portion of D^1. The lengths of A^1 and A^2 are almost the same or A^2 is a little longer than A^1. The following number of rays were counted: D^1 10 D^2 ?, D^3 16, A^1 14, A^2 16. The fin-rays are extremely fragile and were damaged in most of the specimens whilst in the trawl. The pectorals have their bases very low down. Their upper margin is thus on a line with the lowermost margin of the eye, The ventrals are placed a little in front but otherwise close to the pectorals. They reach almost halfway to the anus.

The condition of the pigment is of great interest. First of all must be mentioned, that though the pigment is extremely well preserved, not the slightest trace of a mediolateral streak is shown by any of the specimens examined, and a confusion of this species with the species of the first main group (*G. callarias, virens, pollachius* and *saïda*) is thus at once excluded. The greater part of the sides is unpigmented. A ventral row of chromatophores extends from the anus almost to the beginning of the caudal fin. The dorsal aspect is somewhat densely covered with pigment. There are 5 distinct dorsal groups especially, the first at the beginning of D^1, the second at the beginning of D^2, the third[1] between D^2 and D^3, the fourth at the beginning of D^3 and the fifth halfway between

[1] In contrast to the other specimens, the one figured shows practically no sign of the third group of pigment.

the beginning of D^3 and the beginning of the caudal fin. Even the end of the tail is somewhat strongly pigmented.

As mentioned, the greater part of the sides is unpigmented; some specially characteristic transverse bars of pigment are present, however, the most posterior of which opposite the hindmost (fifth) dorsal group consists of a few, very large and prominent chromatophores. The anterior transverse bars are much less evident, and only traces of them really remain. The bar-arrangement of the pigment decreases in distinctness with age, but can still be detected in specimens of ca. 7 cm. in length.

Holt & Calderwood (1895, p. 435), who have examined still younger stages than I have, speak as follows regarding the young of *Gadiculus*: ". . . but the top of the head and dorsum are speckled with dark chromatophores. These, in specimens of about an inch (1 inch = ca. 25 mm.), show a tendency towards an arrangement into 5 transversal bars, of which some traces remain in specimens of 3 inches".

There is no need to proceed to the description of still older stages, as the species is so characteristic and at once easily recognised by the size of the eyes and the pits on the head. The number of fin-rays in the dorsal and anal fins is also very characteristic.

Material

We are not yet acquainted with the larval and postlarval stages of this species. The distribution of the pigment will probably enable even the very young stages to be readily identified. The absence of a mediolateral pigment streak is very important.

Verification of the determinations

This was extremely easy, as I could detect, even in the smallest specimens examined, the pits on the head which distinguish *Gadiculus argenteus*. The following number of rays was found in 3 of the larger specimens from Ireland and the Skager Rak.

D^1	10	?	?
D^2	11	11	12
D^3	16	15	16
A^1	13	15	17
A^2	17	17	17

Collett (1901, p. 13) gives the following:

D^1	10	10	11
D^2	12	11	12
D^3	19	15	18
A^1	17	12	13
A^2	19	15	17

For a specimen examined by him Günther (1874, p. 138) gives: D^1 9 or 10, D^2 13, D^3 18, A^1 17, A^2 16, and Vaillant (1888, p. 301): D^1 9, D^2 14, D^3 16, A^1 18, A^2 15.

Summarising these, we have:

D^1	D^2	D^3	A^1	A^2
9—11	11—14	15—18	12—18	15—19

In the specimen of 41 mm. in length described above the following number of rays was found: D^1 10, D^2 ?, D^3 16, A^1 14, A^2 16; numbers which quite agree with the ray formula for *Gadiculus*, the only species indeed that could be in question owing to the pigmentation and other features.

Occurrence within the region investigated

Pelagic young of *Gadiculus* are not yet anywhere known, and such early stages as that described have hitherto only been found off the coast of Ireland. According to Holt & Calderwood its occurrence there is characterised by its living on the margin of the ocean abyss, from which it neither descends into great depths nor comes into the quite shallow waters.

Whether *Gadiculus argenteus* like the *Gadus*-species has pelagic eggs and young is not known and cannot be decided beforehand.

Additional note to the description of *Gadiculus argenteus*

After the above description had been completed, my observations on the "Thor" during May and June 1905 have shown, that the postlarval young of *Gadiculus argenteus* (in all stages down to ca. 5 mm.) live pelagically in quantities in the warm Atlantic waters between the Færoes and Scotland and west of the British Isles. A description of these accompanied by figures, which is to be given later, will show, that the *Gadiculus*-young are so different from the *Gadus*-species even in the youngest stages, that a confusion between them is out of the question. In form the youngest postlarval stages are most like the haddock (*G. aeglefinus*) or rather the *Motella*-genus. The youngest stages (ca. 5 mm.) have only one, very short and well-marked pigment-bar, the one, namely, which corresponds to the most posterior in the specimen represented in Pl. III, Fig. 25. At a length of ca. 15 mm. indications of transverse bars sometimes also appear medially on the sides anterior to the original bar, which is still by far the most distinct.

III. ON THE DETERMINATION OF THE *GADUS*-SPECIES IN THE PELAGIC, POSTLARVAL STAGES

In the preceding section a description has been given of the developmental history of the various species, and in doing so, greater weight has in general been laid on representing the differences in the various stages for each single species as the result of progressive development, than upon showing the differences between the various species. The characters which distinguish the species are certainly to be found in the preceding descriptions, which might therefore be used in all cases for any exact investigation, but for the beginner and on the whole for those who have to sort out and arrange provisionally a large collection containing several species, a brief summary of the principal diagnostic features will without doubt be useful for rapid orientation. I shall endeavour to give such a summary in the following pages, but first of all some general remarks may be made.

With our present knowledge[1] it will in general be possible to identify most of the pelagic, postlarval stages of almost all the *Gadus*-species, when well-preserved specimens are to hand. It must be said, however, that the determination of the delicate, pelagic *Gadus*-young will naturally never be an altogether easy task, especially in the case of collections from waters where almost all the species occur. In all cases a certain amount of practice and experience in judging the extent of the variation within each species will be necessary. We have to remember firstly, that a species may vary to a certain extent according to the different waters in which it occurs, and secondly, that the different individuals of the same species can also undergo variation within one and the same region. From the latter it results, that of a number of specimens belonging to the same species a certain proportion deviate in one way or another from the typical appearance of the species, perhaps approaching at the same time some other nearly allied species. Doubtful cases may arise in this way and in greater degree naturally, the further back in development the specimens in question are, as one has fewer characters to depend upon. According to my experience, however, such an overwhelmingly large percentage of the specimens can be determined with certainty even in the most unfavourable circumstances by means of the characters given, that all practical ends may be considered attained[2].

Variation may thus to a certain extent produce difficulties in the determination of pelagic *Gadus*-young. A second difficulty, over which one is partly master, arises from faulty preservation. A badly preserved young fish, where for example the pigment is wholly or partly wanting, or where the fins (or developing fins) are damaged or collapsed, so that one cannot see their form, relative position etc., will in many cases be indeterminable, even though relatively far forward in development. The method

[1] Where gaps still occur in our knowledge, they have been mentioned in the previous descriptions of the separate species (see under the headings "Material").

[2] The condition of things in the southern part of the North Sea is perhaps a few per cent less favourable than elsewhere (cf. additional Note, p. 77).

of preservation is thus an important matter, from which depends how far one can penetrate in the determination of a collection. It may therefore be recommended to spend as much labour as possible on the preservation (cf. page 4).

I shall now give a schematic summary of the principal diagnostic characters for the various species. As the same character is not sufficient for the determination of all the postlarval developmental stages, it is necessary to divide the developmental series into three sections. The first, A, contains the youngest postlarval stages up to a length of about 8—10 mm., the second, B, the stages from about 8—10 mm. to about 15—20 mm., the third, B, stages with a length of about 15—20 mm. to about 30 mm.

A. The youngest postlarval developmental stages up to about 8—10 mm. in length

I. Main group. 3 (or 2) postanal transverse bars of pigment (3, 2, 1) are present, arranged according to the type represented on page 29.

(a) Bar 1 is present.

Only the ventral portion of bar 1 present. Dorsal pigment less pronounced than the ventral ..... *Gadus callarias* (Fig. 1)

Only the dorsal portion or both dorsal and ventral portions of bar 1 present. Dorsal pigment more pronounced than the ventral ..... *Gadus saida* (Fig. 4)

(b) Bar 1 absent. (See additional note p. 77.)

The bar-arrangement quickly disappears owing to the early fusion of the dorsal portions as also of the ventral portions of the pigment. Both dorsal and ventral streaks extend far back towards the tail, the unpigmented end of which is in consequence short ..... *Gadus pollachius* (Fig. 3)

The bars remain separate for a long time. Both dorsal and ventral portions of bar 2 are somewhat short, so that the unpigmented portion of the end of the tail is long ..... *Gadus virens* (Fig. 2)

II. Main group. Postanal transverse bars arranged according to the type represented on page 29 are absent[1].

(a) The postanal pigment ends abruptly a considerable distance in front of the end of the tail.

Dorsal pigment extends further back than the ventral ..... *Gadus Poutassou* (Fig. 16)

Dorsal pigment does not extend further back than the ventral ..... *Gadus luscus*

(b) The postanal pigment does not end abruptly a considerable distance in front of the end of the tail.

(α) The most pronounced and constant portions of the pigment are the anterodorsal and abdominal. Posterodorsal and preanal pigment very weak or wanting. The body in front of the anus is very plump ..... *Gadus aeglefinus* (Fig. 10)

(β) The most conspicuous portions of the pigment are the postanal ventral and dorsal and the anterodorsal is not specially prominent. Preanal pigment distinct.

The dorsal row of pigment generally extends unbroken from the pectoral region to near the end of the tail. The ventral row consists of numerous small, closely placed chromatophores ..... *Gadus merlangus* (Fig. 11)

[1] In *Gadiculus argenteus* the postanal pigment is restricted to one, very distinct, black transverse bar situated some distance in front of the end of the tail.

The dorsal row of pigment is broken on the region over the anus and consists of few but larger and less closely placed chromatophores than in *Gadus merlangus* ..... *Gadus Esmarki*[1] (Fig. 12)

B. Stages from about 8—10 up to about 15—20 mm. in length

I. Main group. Mediolateral streak present.

(a) The postanal pigment does not end abruptly some distance in front of the end of the tail, which consequently is not in sharp contrast to the pigmented portion of the body. Pigment is present as a rule on the end of the tail.

Preanal pigment is well-developed and extends posteriorly almost to the anus. The end of the notochord is already slightly bent upwards at a length of 11 mm. The body not extremely elongated ..... *Gadus callarias* (Plate I)

Preanal pigment is weak and far from reaching to the anus posteriorly. The end of the notochord is still straight at a length of 16 mm. The body extremely elongated ..... *Gadus saïda* (Plate I)

(b) The postanal pigment ends abruptly some distance in front of the end of the tail, which is pale and unpigmented, thus standing out in marked contrast to the pigmented portion of the body.

The preanal pigment is well-developed and reaches posteriorly almost to the anus. The postanal pigment is evenly distributed over the sides and is very conspicuous. The caudal fin is very broad and square posteriorly. The anus lies a considerable distance in front of D^2 ..... *Gadus pollachius* (Plate I)

The preanal pigment is weak and does not reach posteriorly to the anus. The sides are densely pigmented with exception of a lighter, roundish part centrally, where the mediolateral streak is often broken. The anus lies a little in front of D^2 *Gadus virens* (Plate I)

II. Main group. Mediolateral streak wanting[2].

(a) The postanal pigment ends abruptly a considerable distance in front of the end of the tail. Apart from this the greater part of the sides is covered by pigment.

The body unusually high and narrowing abruptly towards the end of the tail. The dorsal pigment does not reach further back than the ventral ..... *Gadus luscus* (Plate III)

The body not unusually high and not narrowing abruptly towards the end of the tail. The dorsal pigment reaches further back than the ventral .... *Gadus Poutassou* (Plate III)

(b) The postanal pigment does not end abruptly some distance in front of the end of the tail.

(α) The body unusually short and plump. Pectorals and ventrals generally strongly pigmented. Posterodorsal and preanal pigment most often very weak or wanting. Anus far back, under D^2 ..... *Gadus aeglefinus* (Plate II)

(β) The body not unusually short and plump. Preanal and posterodorsal pigment generally distinct. Pectorals and ventrals not pigmented.

(x) Greater part of the sides overstrewn with pigment. Anus far forward, under D^1. No specially large chromatophores present. A^1 much longer than A^2 *Gadus merlangus* (Plate II)

[1] I am not acquainted with the pigmentation of *G. minutus* in these stages.

[2] *Gadiculus argenteus*, which is lacking in mediolateral pigment, is at once distinguished from the *Gadus*-species by the single black posterolateral bar.

(γ) Greater part of the sides unpigmented, the postanal pigment being almost exclusively restricted to the ventral and dorsal rows, which consist of large, stellate chromatophores. A^1 but slightly longer than A^2.

The body is much thicker in front than behind the anus. Eyes very large. Development of D^1 rapid ..... *Gadus minutus* (Plate III)

The body is not much thicker in front than behind the anus. Eyes not unusually large. D^1 very low (development slow)..... *Gadus Esmarki* (Plate III)

C. Stages from about 15—20 mm. up to ca. 30 mm.

I. Main group. Mediolateral streak present.

(a) Anus under D^2.

The body unusually elongated. A^1 reaches further back than D^2. Caudal fin forked. Development of the rays very slow. Eyes very large ..... *Gadus saïda* (Plate I)

The body not unusually elongated. A^1 does not reach further back than D^2. Caudal fin square posteriorly ..... *Gadus callarias* (Plate I)

(b) Anus under D^1.

The anus under the anterior 1/3 of D^1. Caudal fin very broad posteriorly and square. Deep black pigment spots fill up a great part of the unpaired fins *Gadus pollachius* (Plate I)

The anus under the posterior 1/3 of D^1. Caudal fin concave posteriorly. The fins, especially the caudal, somewhat less pigmented than in *G. pollachius* ..... *Gadus virens* (Plate I)

II. Main group. Mediolateral streak wanting[1].

(a) Anus under D^2..... *Gadus aeglefinus* (Plate II)

(b) Anus under D^1.

(α) Greater part of the sides densely pigmented. Anus under the first 1/3 of D^1.

(x) A^1 and A^2 connected. Body unusually high..... *Gadus luscus* (Plate III)

(y) A^1 and A^2 separated. Body not unusually high.

D^2 unusually short and separated from D^3 by a large interspace.. *Gadus Poutassou* (Plate III)

D^2 not unusually short nor separated from D^3 by a large interspace... *Gadus merlangus* (Plate III)

(β) Greater part of the sides unpigmented. Anus under the posterior 1/3 of D^1.

Snout rounded; lower jaw does not extend much further forward than the upper. Diameter of the eye almost equal to the length of the snout. Body very thick in front of the anus (club-shaped anteriorly). D^1 close to D^2... *Gadus minutus* (Plate III)

Snout flat; lower jaw extends somewhat further forward than the upper. Diameter of the eyes much larger than the length of the snout. Body narrow both in front of and behind the anus. D^1 separated by a short interspace from D^2.. *Gadus Esmarki* (Plate III)

Lastly, I may describe a little more closely the diagnostic characters of the economically most important species.

1. **Cod** (*G. callarias*). The cod can almost always be distinguished from the green cod by the smaller eyes and less conspicuous pigmentation. In the youngest postlarval stages it is generally distinguished from the green cod by there being a few subnotochordal chromatophores at the end of the tail (cf. additional note p. 77). The ventral pigment is relatively more strongly developed than in

[1] *Gadiculus argenteus*, where a mediolateral streak is wanting, differs from the *Gadus*-species by the presence of a posterolateral bar of pigment.

the green cod, and the ventral portion of bar 2 extends further back than the dorsal (in the green cod both are alike or the dorsal is longer than the ventral). The ventral portion of bar 3 is more developed than in the green cod, and the bars coalesce together earlier in general (in contrast to the green cod it is generally the ventral portions of the bars which coalesce first). The preanal pigment is in general well-marked and reaches from the throat to or almost to the anus (in the green cod the preanal pigment is generally weak and far from reaching to the anus posteriorly).

In somewhat older postlarval stages the cod is distinguished from the green cod by not having the end of the tail pale (unpigmented), and by the pigment not ending abruptly posteriorly. (In the green cod the end of the tail generally becomes pigmented at a length of some twenty mm.). The pigment is generally less conspicuous and dense. Thus the mediolateral streak is not so constant nor reaches so far forward in general as in the green cod (and pollack). The fins are also less pigmented than in the green cod (and pollack). The anus lies more posteriorly than in the green cod (under D^2 in the cod, under D^1 in the green cod). The ventrals are much longer than in the green cod. In the early stages the cod is readily distinguished from the other species by the chequered pigmentation and the long barbule.

From the pollack (*G. pollachius*) the cod is easily distinguished by its less developed pigmentation. The mediolateral streak especially is much more constant in the pollack and reaches further forward than in the cod, which in addition has no pale (unpigmented) region at the end of the tail. Finally, the position of the anus, the relation between the lengths of A^1 and A^2 as well as the pigmentation of the fins are very different in the two species.

Concerning the polar cod (*G. saïda*), see page 24 et seq.

2. **Green cod** (*G. virens*). The differences between the green cod and cod (*G. callarias*) have just been mentioned under the cod.

In the youngest stages the green cod is distinguished from the pollack (*G. pollachius*), in that the bars remain separate much later and by the longer unpigmented portion of the tail. The preanal pigment is generally weaker and far from reaching to the anus posteriorly. In somewhat older stages the green cod is distinguished from the pollack, in that the end of the tail is later covered by pigment than in the latter, also by a lighter (less pigmented) part centrally on the sides, where further the mediolateral streak is often broken or fainter, by the weaker preanal pigment, and by the fins becoming covered with pigment later. Also, the anus lies further back (in the green cod under the posterior, in the pollack under the anterior third of D^1), A^1 is relatively longer and lower than A^2, and the caudal fin is more forked and not so broad posteriorly as in the pollack. Finally, the snout is shorter and blunter, and the ventral fins more pointed than in the pollack.

3. **Pollack** (*G. pollachius*). The distinguishing characters of the pollack have already been mentioned under the cod and green cod.

4. **Haddock** (*G. aeglefinus*). The haddock is in general easily distinguished at all stages from other species, and is specially remarkable in having a short and plump appearance.

From the whiting (*G. merlangus*), the haddock is distinguished in the youngest stages not only by its form, but also in that the preanal pigment is weak and is far from reaching to the anus posteriorly, also by the almost total absence of posterodorsal pigment, whilst the anterodorsal pigment on the contrary is strongly developed. In older stages the form, size and pigmentation of the ventral and pectoral fins, the strong development of the anterodorsal pigment and the position of the anus under D^2 are sufficient to differentiate the haddock from all other species.

From the pout (*G. luscus*) and poutassou (*G. Poutassou*) the haddock is immediately distinguished by the lack of well-developed postanal dorsal and ventral streaks.

From the poor cod (*G. minutus*) and Norway pout (*G. Esmarki*) the haddock is recognised in the youngest stages by the form, by the weak preanal pigment and by not having the large stellate chromatophores, which compose the dorsal and especially the ventral pigment in the two first-mentioned species. The characteristics have been mentioned above, by means of which the older stages can easily be separated from those of all other species.

5. **Whiting** (*G. merlangus*). The characters which distinguish the whiting from the haddock (*G. aeglefinus*) have been mentioned under the latter species.

From *G. luscus* and *G. Poutassou* the whiting is distinguished in the youngest stages, in that the postanal pigment does not end abruptly some distance from the end of the tail. In older stages the whiting is easily distinguished from *G. luscus* by the break between A^1 and A^2 and the smaller height of the body, and from *G. Poutassou* because D^2 and D^3 are not separated by a large interspace.

From *G. Esmarki* the whiting in the youngest stages is generally distinguished by the continuous dorsal pigment and the numerous, smaller and more closely placed ventral chromatophores, which are all marginal. I am unable to throw light upon the characters differentiating *G. minutus* and *G. merlangus* in the very youngest postlarval stages.

In older stages the whiting is easily distinguished from *G. Esmarki* and *G. minutus*, in that the sides soon become covered by pigment, by the anus being placed further forward and by A^1 being much longer than A^2.

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SMITT, F. A.: Skandinaviens Fiskar. 3 vol., Stockholm **1892.**

STEINDACHNER (1868) = STEINDACHNER, F.: Ichthyologischer Bericht über eine nach Spanien und Portugal unternommene Reise, *Sitz. Ber. Akad d. Wissensch.,* Wien, LVII, **1868.**

VAILLANT (1888) = VAILLANT, L.: Expéditions Scientifiques du Travailleur et du Talisman, Poissons, 28 plates, Paris **1888.**

WILLIAMSON (1902) = WILLIAMSON, H. CHAS.: A Comparison between the Cod (*Gadus callarias,* Linn.), the Saithe (*Gadus virens,* Linn.), and the Lythe (*Gadus pollachius,* Linn.), in respect to certain External and Osteological Characters, *20th Annual Report of the Fishery Board for Scotland,* **1902,** p. 228, plates IV—XI.

WINTHER (1879—80) = WINTHER, G.: Prodromus Ichthyologiae Danicae, *Naturhistorisk Tidsskrift,* 3 Række, 12 Bind, **1879—80,** p. 1.

PLATE I[1])

Fig. 1. *G. callarias,* **length 4 1/2 mm.,** "Thor", Stat. 106, 5th June 1903, N. of Skæret, Heymaey, (Vestmannaeyjar), South Iceland. Young-fish trawl on the surface.
Fig. 2. *G. callarias,* **length 6 1/2 mm.,** same haul as 1.
Fig. 2a. Same specimen as Fig. 2 seen from the ventral aspect.
Fig. 3. *G. callarias,* **length 9 mm.,** "Thor", Stat. 140, 16th June 1904, West Iceland, 65° 56′ N., 23° 56′ W., depth: 38 meters. Young-fish trawl, 40 meters wire.
Fig. 4. *G. callarias,* **length 11 mm.,** "Thor", Stat. 163, 27th June 1904, West Iceland, 65° 10·5′ N., 24° 05′ W., depth: 79 meters. Young-fish trawl, 85 meters wire.
Fig. 5. *G. callarias,* **length 13 mm.,** same haul as 4.
Fig. 6. *G. callarias,* **length 16 mm.,** same haul as 4.
Fig. 7. *G. callarias,* **length 20 mm.,** same haul as 4.
Fig. 8. *G. callarias,* **length 30 mm.,** "Thor", Stat. 176, 18th July 1903, South Iceland, 63° 27′ N., 19° 37′ W., depth: 65 meters. Young-fish trawl on the surface.
Fig. 9. *G. callarias,* **length 46 mm.,** "Thor", Stat. 178, 19th Juli 1903, South Iceland, 63° 42′ N., 17° 34′ W., depth: 70 meters. Young-fish trawl on the bottom.
Fig. 10. *G. virens,* **length 4 mm.,** same haul as 1.
Fig. 11. *G. virens,* **length 6 3/4 mm.,** same locality as 4. Young-fish trawl, 15 meters wire.
Fig. 11a. Same specimen as 11, seen from the ventral aspect.
Fig. 12. *G. virens,* **length 9 mm.,** same haul as 4.
Fig. 13. *G. virens,* **length 11 mm.,** "Thor", Stat. 154, 3rd July 1903, West Iceland, 65° 29.5′ N., 24° 34′ W., depth: 42 meters. Young-fish trawl on the surface.
Fig. 14. *G. virens,* **length 12 1/2 mm.,** "Thor", Stat. 155, 4th July 1903, West Iceland, 65° 11′ N., 26° 38′ W., depth: 66—76 meters. Young-fish trawl on the surface.
Fig. 15. *G. virens,* **length 15 mm.,** same haul as 4.
Fig. 16. *G. virens,* **length 20 mm.,** same haul as 13.
Fig. 17. *G. virens,* **length 23 mm.,** same haul as 4.
Fig. 18. *G. virens,* **length 30 mm.,** "Thor", Stat. 180, 19th July 1903, South Iceland, 63° 39′ N., 16° 18′ W., depth: 100 meters. Young-fish trawl on the surface.
Fig. 19. *G. saïda,* **length 6 1/2 mm.,** "Thor", Stat. 151, 2nd July 1903, North Iceland, 66° 17′ N., 21° 14′ W., depth: 180 meters. Young-trawl on the surface.
Fig. 19a. Same specimen as 19, seen from the ventral aspect.
Fig. 20. *G. saïda,* **length 8 mm.,** same haul as 19.
Fig. 21. *G. saïda,* **length 11 mm.,** same haul as 19.
Fig. 22. *G. saïda,* **length 13 mm.,** East Greenland, Jameson Land just on margin of strand by very low water. 3rd Aug. 1891, Ryder's Expedition. Spirit preparation.
Fig. 23. *G. saïda,* **length 16 mm.,** same place and date as 22. Spirit preparation.
Fig. 24. *G. saïda,* **length 46 mm.,** East Greenland, Hurry Inlet, Jameson Coast, 7—0 fathoms, eel-seine, 7th Aug. 1900. East Greenland Expedition 1900. Spirit preparation.
Fig. 25. *G. pollachius,* **length 7 1/4 mm.,** Norwegian fisheries investigations, 15th June 1904, Søndeled Fjord (near Jæderen).
Fig. 26. *G. pollachius,* **length 11 3/4 mm.,** Eddystone (English Channel), 8th May 1897, on the surface. Spirit preparation.
Fig. 27. *G. pollachius,* **length 15 mm.,** same haul as 26. Spirit preparation
Fig. 28. *G. pollachius,* **length 18 1/4 mm.,** Rame Head, Plymouth, 8th June 1897, on the surface. Spirit preparation.
Fig. 29. *G. pollachius,* **length 20 1/4 mm.,** Plymouth, 8th June 1897, on the surface. Spirit preparation.
Fig. 30. *G. pollachius,* **length 32 mm.,** Norwegian fisheries investigations, 15th July 1904, Søndeled Fjord (near Jæderen).

[1] When nothing to the contrary is said, the specimens figured have been preserved in formalin.

PLATE II

Fig. 1. *G. merlangus,* length 6½ mm., "Thor", Stat. 171, 2nd July 1904, 63° 46′ N., 22° 56′ W., depth: 150 meters. Young-fish trawl, 30 meters wire.
Fig. 2. *G. merlangus,* length 7 mm., same haul as 1.
Fig. 2a. Same specimen as 2, seen from the ventral aspect.
Fig. 3. *G. merlangus,* length 8 mm., same haul as 1.
Fig. 4. *G. merlangus,* length 9 mm., "Thor", Stat. 189, 15th July 1904, South Iceland, 63° 30′ N., 21° 03′ W., depth: 109 meters. Young-fish trawl 50 meters wire.
Fig. 5. *G. merlangus,* length 11 mm., "Thor", Stat. 188, 12th July 1904, South Iceland, 63° 30′ N., 20° 14′ W., depth: 80 meters. Young-fish trawl on the surface.
Fig. 5a. Same specimen as 5, seen from the dorsal aspect.
Fig. 5b. Same specimen as 5, seen from the ventral aspect.
Fig. 6. *G. merlangus,* length 13 mm., "Thor", Stat. 157, 4th July 1903, Faxebugt (Iceland), 64° 23′ N., 22° 52′ W., depth: 88 meters. Young-fish trawl on the surface.
Fig. 7. *G merlangus,* length 16 mm., same haul as 6.
Fig. 8. *G. merlangus,* length 23 mm., "Thor", Stat. 176, 18th July 1903, South Iceland, 63° 27′ N., 19° 37′ W., depth: 65 meters. Young-fish trawl on the surface.
Fig. 9. *G. merlangus,* length 32½ mm., same haul as 8.
Fig. 10. *G. aeglefinus,* length 6¾ mm., "Thor", Stat. 112, 10th June 1903, Faxebugt (Iceland), 64° 10′ N., 22° 58′ W., depth: 70 meters. Young-fish trawl on the surface.
Fig. 11. *G. aeglefinus,* length 9 mm., "Thor", Stat. 154, 3rd July 1903, West Iceland, 65° 29.5 N, 24° 34′ W., depth: 42 meters. Young-fish trawl on the surface.
Fig. 12. *G. aeglefinus,* length 11¼ mm., same haul as 11.
Fig. 13. *G. aeglefinus,* length 15 mm., same haul as 11. The free end of the notochord is two strongly represented.
Fig. 13a. Same specimen as 13, seen from the ventral aspect. Gill-covers unnaturally wide open.
Fig. 14. *G. aeglefinus,* length 19 mm., "Thor", Stat. 153, 3rd July 1903, West Iceland, 66° 19′ N., 23° 22′ W., depth: 114 meters. Young-fish trawl on the surface.
Fig. 15. *G aeglefinus,* length 25 mm., "Thor", Stat. 162, 11th July 1903, South Iceland, 63° 40′ N., 21° 58′ W., depth: 157 meters. Young-fish trawl on the surface.
Fig. 16. *G. aeglefinus,* length 29 mm., same haul as 15.
Fig. 17. *G. aeglefinus,* length 43 mm., "Thor", Stat. 176, 18th July 1903, South Iceland, 63° 27′ N., 19° 37′ W., depth: 65 meters. Young-fish trawl near the bottom.

PLATE III

Fig. 1. *G. Esmarki,* length 6¾ mm., "Thor", Stat. 163, 27th June 1904, West Iceland, 65° 10.5′ N., 24° 05′ W, depth: 79 meters. Young-fish trawl 85 meters wire.
Fig. 1a. Same specimen as 1, seen from the ventral aspect.
Fig. 2. *G. Esmarki,* length 8½ mm., "Thor", Stat. 157, 4th July 1903, Faxebugt (Iceland), 64° 23′ N., 22° 52′ W., depth: 88 meters. Young-fish trawl on the surface.
Fig. 3. *G Esmarki,* length 10½ mm., same haul as 2.
Fig. 4. *G. Esmarki,* length 13 mm., "Thor", Stat. 156, 4th July 1903, West Iceland, 64° 39′ N., 23° 40′ W., depth: 91 meters. Young-fish trawl on the surface.
Fig. 4a. Same specimen as 4, seen from the dorsal aspect.
Fig. 4b. Same specimen as 4, seen from the ventral aspect.
Fig. 5. *G. Esmarki,* length 16½ mm., same haul as 4.
Fig. 6. *G Esmarki,* length 19¾ mm., "Thor", Stat 176, 18th July 1903, South Iceland, 63° 27′ N., 19° 37′ W., depth: 65 meters. Young-fish trawl on the surface.
Fig. 7. *G. Esmarki,* length 23 mm., same haul as 6.
Fig. 8. *G. Esmarki,* length 30 mm., same haul as 6.
Fig. 9. *G. Esmarki,* length 54 mm., "Thor", Stat. 278, 29th Aug. 1904, Faxebugt (Iceland), 64° 05′ N., 22° 40′ W., depth: 40 meters. Young-fish trawl on the bottom.
Fig. 10. *G. Poutassou,* length 6⅔ mm., "Thor", Stat. 87, 2nd June 1903, Atlantic Ocean south from Iceland, 61° 40′ N., 13° 33′ W., depth: more than 1000 fathoms. Young-fish trawl on the surface.

Fig. 11. *G Poutassou,* **length 6²/₃ mm.,** "Thor", Stat. 88, 2nd June 1903, Atlantic Ocean south from Iceland, 61° 30′ N., 13° 33′ W., depth: $\frac{\cdot}{1900}$ meters. Young-fish trawl on the surfuce.

Fig. 12. *G. Poutassou,* **length 8¹/₂ mm.,** same haul as 10.

Fig. 13. *G. Poutassou,* **length 10¹/₄ mm.,** same haul as 10.

Fig. 14. *G Poutassou,* **length 13 mm.,** "Thor", Stat. 91, 3rd June 1903, Atlantic Ocean, south from Iceland, 61° 30′ N.. 17° 08′ W., depth: more than 1000 fathoms. Young-fish trawl on the surface.

Fig. 15. *G. Poutassou,* **length 16 mm.,** "Thor", Stat. 92, 3rd June 1903, Atlantic Ocean, south from Iceland, 61° 31′ N., 19° 05′ W., depth: more than 1000 fathoms. Young-fish trawl on the surface.

Fig. 16. *G. minutus,* **length 16 mm.,** Start Bay, Plymouth, 25th May 1897, near the bottom. Spirit preparation.

Fig. 17. *G. minutus,* **length 23 mm.,** Start Bay, Plymouth, 24th May 1897, near the bottom. Spirit preparation.

Fig. 18. *G. minutus,* **length 25 mm.,** Cawsand Bay, Plymouth, 13th June 1902, bottom.

Fig. 19. *G. minutus,* **length 50 mm.,** Søndeled Fjord, (south. Norway), 8—0 fathoms, 23th Sept. 1903.

Fig. 20. *G. luscus,* **length 18 mm.,** Start Bay, Plymouth, 25th May 1897, near the bottom Spirit preparation.

Fig. 21. *G. luscus,* **length 20¹/₂ mm.,** Teignmouth Bay, Plymouth, 1st June 1897, near the bottom Spirit preparation.

Fig. 22. *G. luscus,* **length 24 mm.,** Cawsand Bay, Plymouth, 13th June 1902, bottom.

Fig. 23. *G. luscus,* **length 34 mm.,** Cawsand Bay, Plymouth, 13th June 1902, bottom.

Fig. 24. *G. luscus,* **length 50 mm.,** Cawsand Bay, Plymouth, July 1904, shrimp-trawl.

Fig. 25. *Gadiculus argenteus,* **length** ca. **41 mm.,** west from Ireland, 28th Aug 1901, 199 fathoms. The caudal fin is not correctly drawn perhaps, as it was damaged in all the specimens at hand. In contrast to most of the others, the specimen figured lacked the dorsal pigment-group between the beginning of D^2 and the beginning of D^3.

ADDITIONAL NOTE

On the cruises of the "Thor" in the North Sea during the spring of 1905 I have had the opportunity to examine a large number of young postlarval stages of *G. callarias, aeglefinus* and *merlangus* in the living condition. It thus appeared, that most of the specimens from the southern part of the North Sea (on a line: Esbjerg—Doggerbank—Hull, on the other hand, not the northern part of the North Sea) differed considerably from the normal appearance of the species (known from Iceland, the Færoes, Scotland and the northern part of the North Sea) in that they were often much more weakly pigmented.

Thus, in the tender fry of *G. callarias* the pigment-bar 1, which is normally present elsewhere, was rather often quite absent, just as is the case in *Gadus virens,* and even the mediolateral streak was sometimes very weak without however being quite absent. Nevertheless these young of *G. callarias* could almost always be distinguished with certainty from the other species. In the youngest stages they were distinguishable from *G. aeglefinus* and *merlangus* by the bar-arrangement of the pigment, and in the older by the constant presence of some traces of the mediolateral streak. From *G. virens,* which however did not occur on this line, they could be distinguished by one or several of the following characters: (1) the pigment was much weaker than I have ever seen it in *G virens*; (2) the preanal pigment was as a rule distinct and extended posteriorly almost to the anus; (3) the ventral pigment was most often more strongly developed than the dorsal, and in particular V^3 was often relatively well-developed; (4) V^2 usually extended a little further back than D^2.

The young of *G. merlangus* and *aeglefinus* were most easily distinguished by the first-mentioned having a distinct preanal row of pigment extending right to the anus, which was absent or very weak in *G. aeglefinus*; in the latter the anterodorsal and abdominal pigment was as usually relatively much more developed than the remaining pigment.

ERRATA

Page 1, line 10—11 from above; instead of: Further, the early stages of *these* species....; *read:* Further, the early stages of *the other Gadus*-species.....

460 10/x 1905

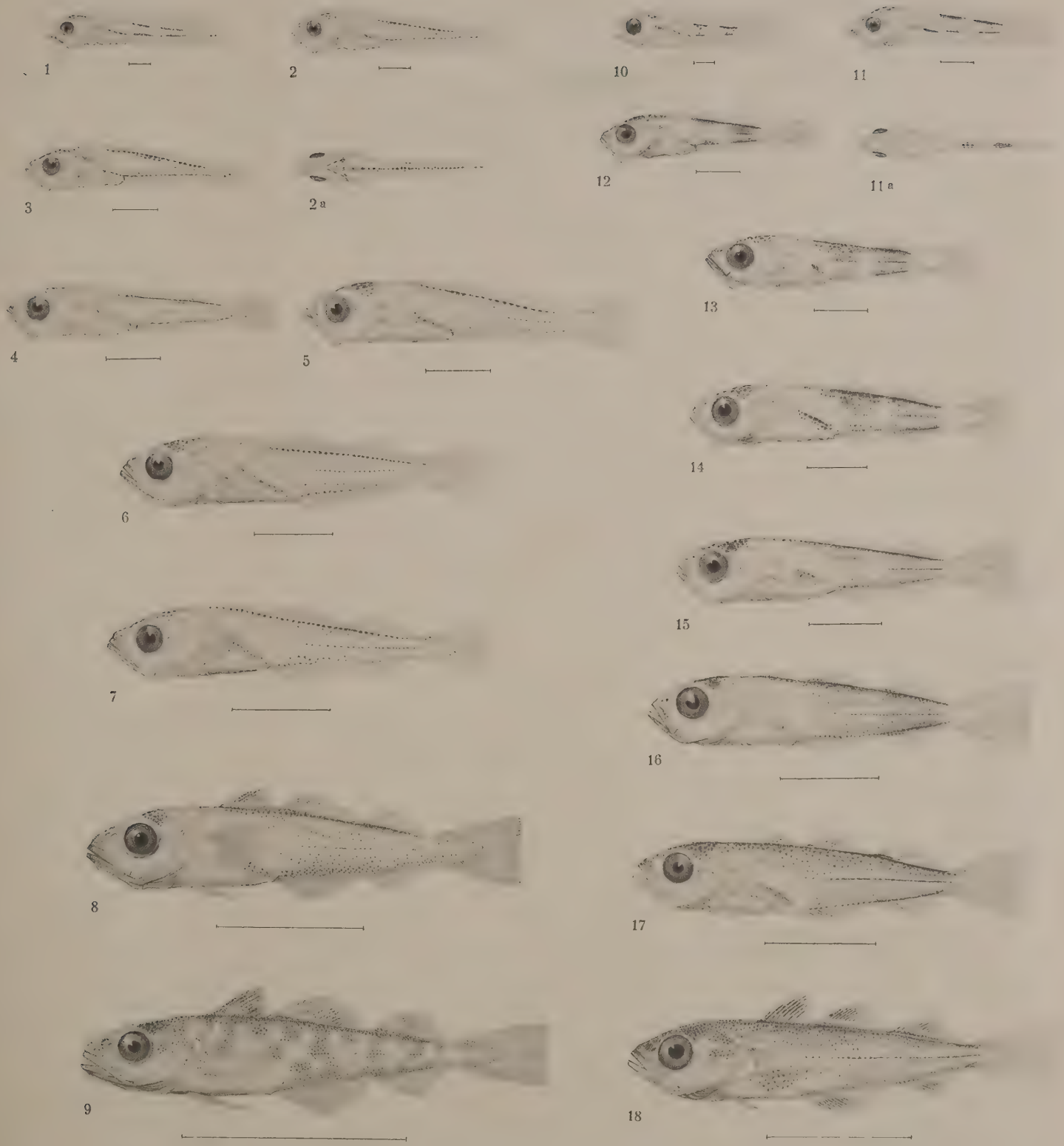
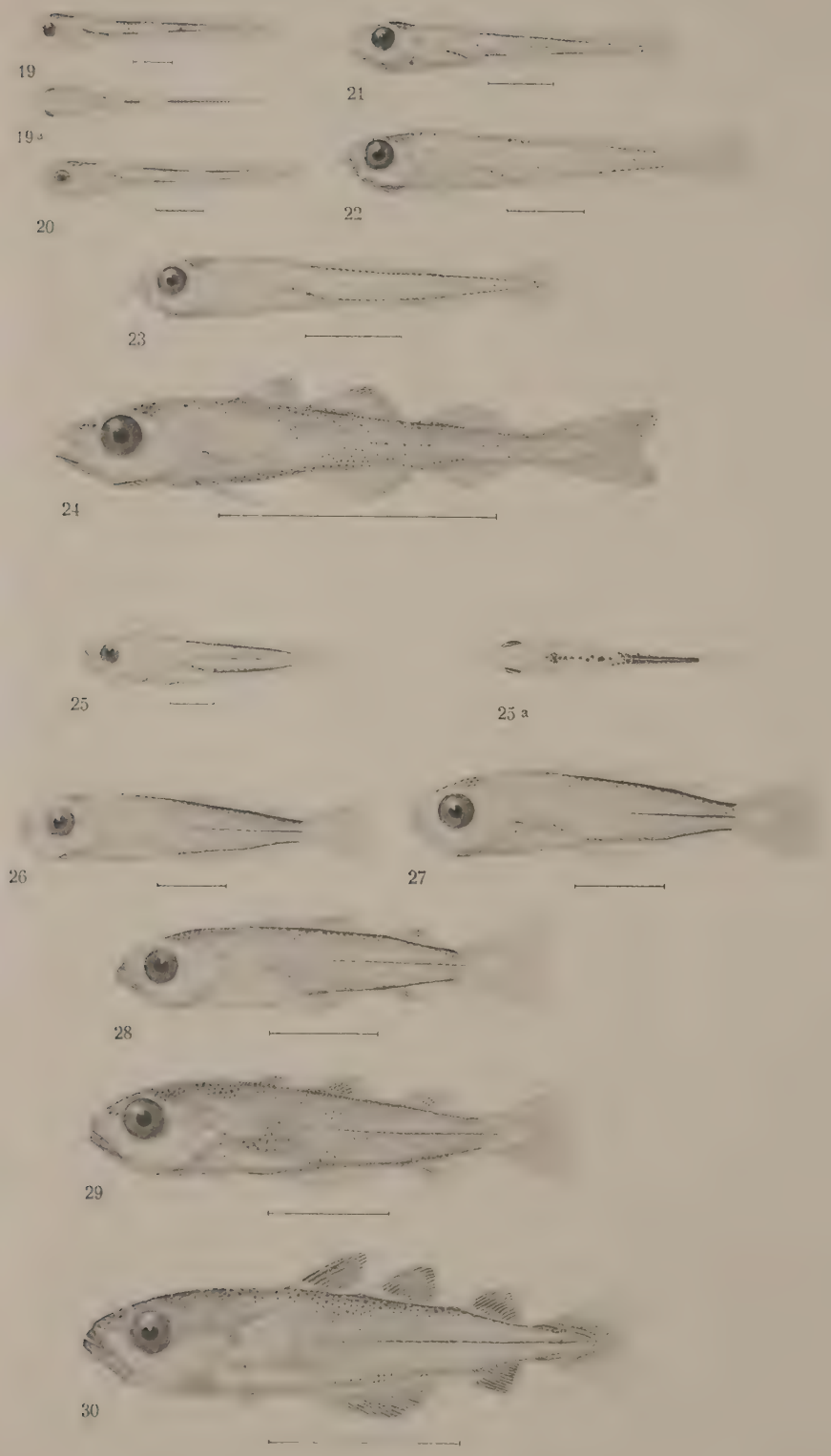


Fig. 1— 9 *Gadus callarias* Linné; Fig. 10—18 *Gadus virens* Linné; Fig. 19—24 *Gadus saïda* Lep

H. V Westergaard et Th. Bloch del.



echin; Fig 25—30 *Gadus pollachius* Linné.

Pacht & Crone phototyp.

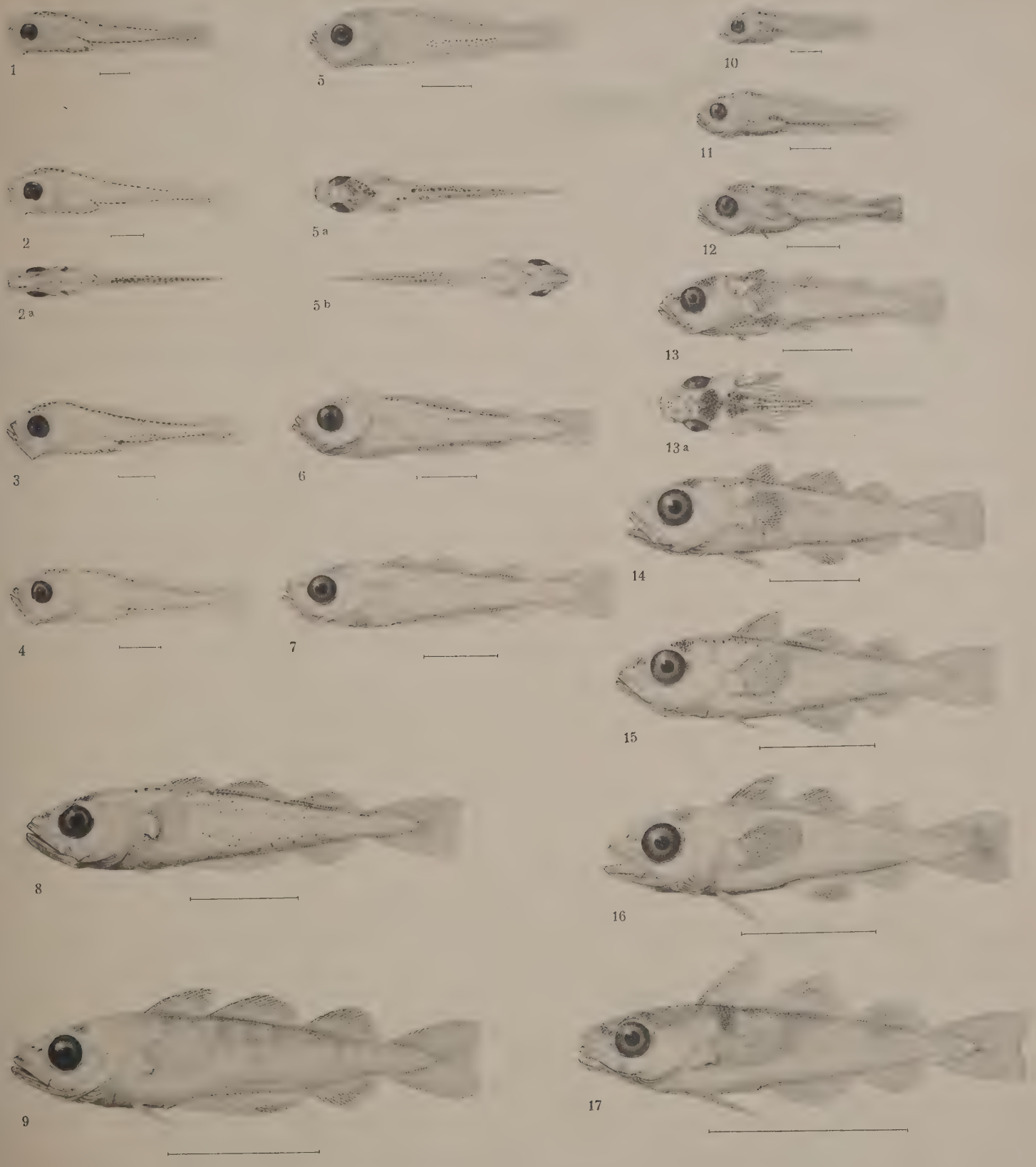


Fig. 1— 9 *Gadus merlangus* Linné; Fig. 10—17 *Gadus aeglefinus* Linné.

Th. Bloch et H. V Westergaard del.

Pacht & Crone phototyp.

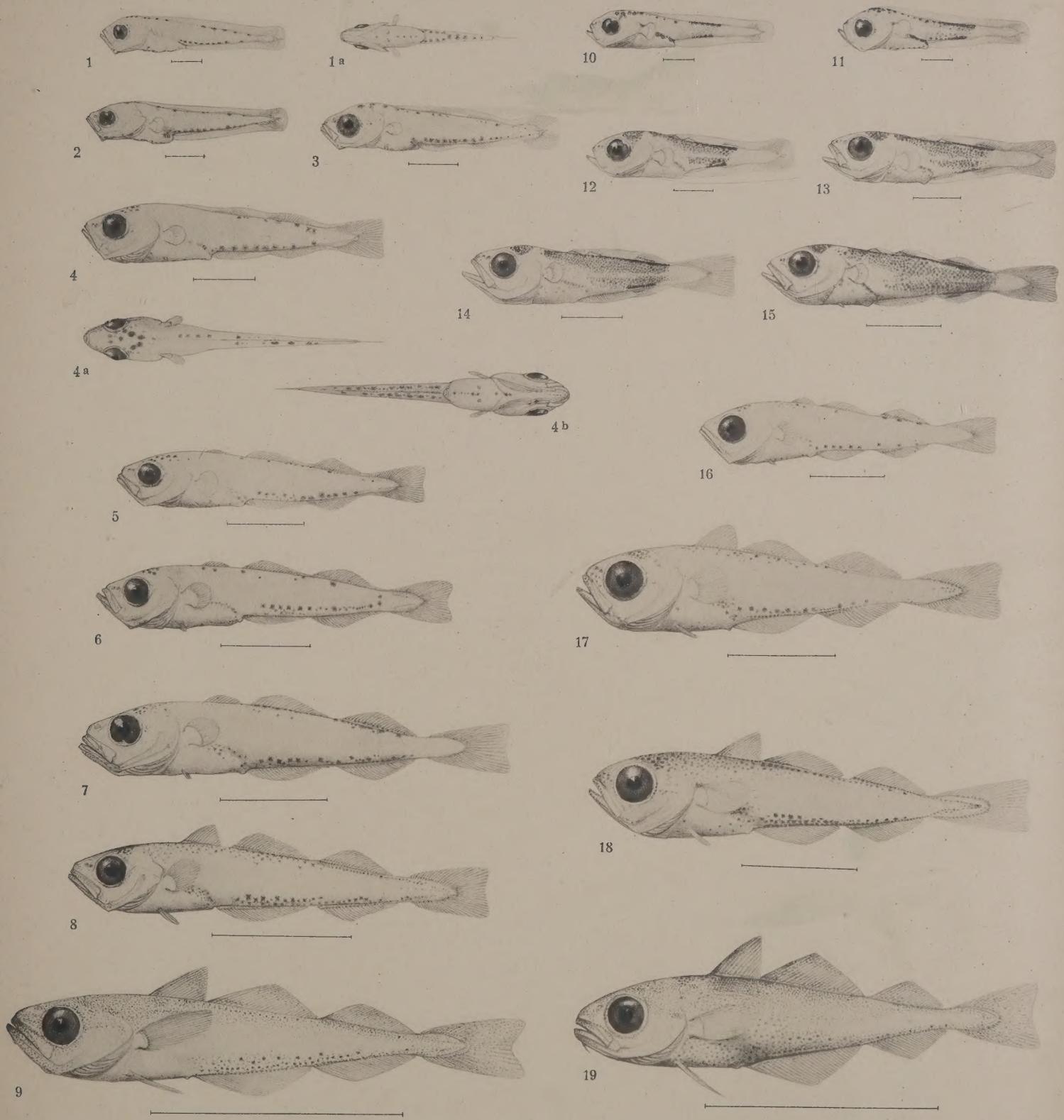
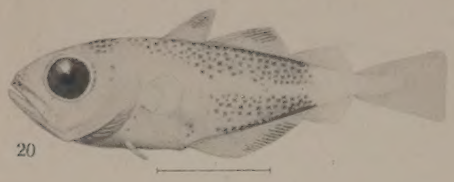


Fig. 1— 9 *Gadus Esmarki* Nilsson; Fig. 10—15 *Gadus Poutassou* (Risso); Fig. 16—19 *Gadus minutus* O. F. Müller; Fig. 20—24 *Gadus*

H. V Westergaard et Th. Bloch del.



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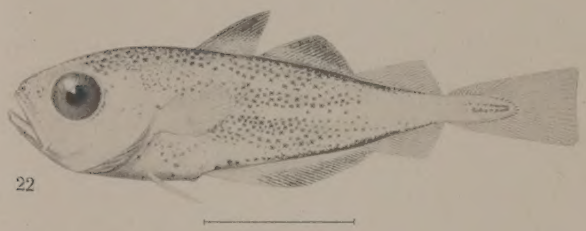

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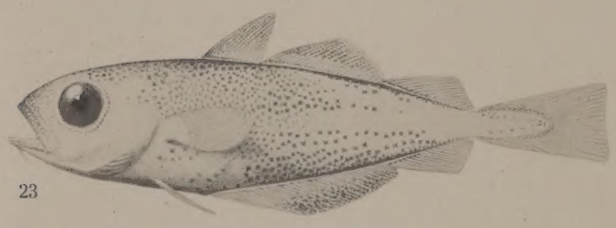

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iscus Linné; Fig. 25 *Gadiculus argenteus* Guichenot.

Pacht & Crone phototyp.